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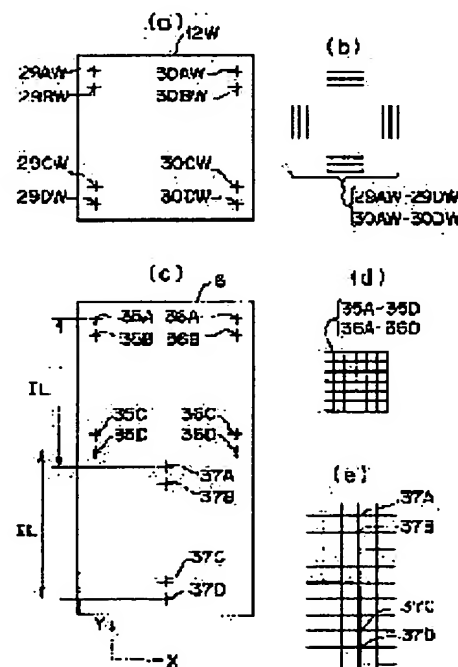
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## (54) PROJECTING EXPOSURE METHOD

(57)Abstract:

PURPOSE: To accurately make a reticle coordinate system correspond to a wafer coordinate system by reducing influence of a lithographic error of a reticle when it is exposed by a slit scanning system.

CONSTITUTION: Two rows of alignment mark images 29AW-29DW and 30AW-30DW are projected on a projected image 12W of a reticle in a scanning direction, and two rows of reference marks 35A-35D and 36A-36D are formed as well on a reference mark plate 6 of the wafer stage side in the scanning direction. The reticle and the plate 6 are moved in the scanning direction, an error of the images 29AW, 30AW and the marks 35A, 36A is obtained by a reticle alignment microscope, an error of the other image and the reference mark is similarly obtained, these errors are corrected by a measuring error of a coordinate measuring system, thereby obtaining a conversion parameter between a reticle coordinate system and a wafer coordinate system.



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**CLAIMS**

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**[Claim(s)]**

[Claim 1] Illuminate the lighting field of a predetermined configuration by the illumination light, and the pattern image on the mask in the lighting field of said predetermined configuration is exposed to the substrate on a stage through a projection optical system. By scanning said mask and said substrate synchronously relatively to the lighting field of said predetermined configuration In the approach of exposing the pattern image of an area larger than the lighting field of said predetermined configuration on said mask on said substrate Two or more marks for measurement are formed towards said relative scan on said mask. The reference mark member by which two or more reference marks were formed in these two or more marks for measurement and a location [ \*\*\*\* / almost ] is arranged on said stage. Said mask and said substrate are moved synchronizing with the direction of said relative scan. Sequential measurement of the amount of location gaps of one mark for measurement in two or more marks for measurement on said mask and the reference mark to which it corresponds on said stage is carried out. The projection exposure approach characterized by asking for the response relation between the system of coordinates on said mask, and the system of coordinates on said stage from each amount of location gaps of said two or more marks for measurement and said two or more reference marks.

[Claim 2] Illuminate the lighting field of a predetermined configuration by the illumination light, and the pattern image on the mask in the lighting field of said predetermined configuration is exposed to the substrate on a stage through a projection optical system. By scanning said mask and said substrate synchronously relatively to the lighting field of said predetermined configuration In the approach of exposing the pattern image of an area larger than the lighting field of said predetermined configuration on said mask on said substrate The alignment system of the off-axis method for detecting the location of the mark for positioning on said substrate near said projection optical system is arranged. Two or more marks for measurement are formed towards said relative scan on said mask. The reference mark member in which the 1st and 2nd reference marks were formed at spacing corresponding to spacing of the reference point in the exposure field of said projection optical system and the reference point of the alignment system of said off-axis method is arranged on said stage. Where said 2nd reference mark on said criteria member is observed by the alignment system of said off-axis method Move said mask towards said relative scan, and sequential measurement of the amount of location gaps of one mark for measurement in two or more marks for measurement on said mask and said 1st reference mark on said stage is carried out. From the amount of location gaps of said 2nd reference mark observed by the average of each amount of location gaps of said two or more marks for measurement and said 1st reference mark, and the alignment system of said off-axis method The projection exposure approach characterized by asking for spacing of the reference point in the exposure field of said projection optical system, and the reference point of the alignment system of said off-axis method.

[Claim 3] While making it correspond to two or more marks for measurement on said mask and forming two or more said 1st reference mark on said reference mark member Two or more said 2nd reference mark is formed from these two or more 1st reference marks at spacing corresponding to spacing of the reference point in the exposure field of said projection optical system, and the reference point of the alignment system of said off-axis method, respectively. Said mask and said stage are moved synchronizing with the direction of said relative scan. While carrying out sequential measurement of the amount of location gaps of one mark for measurement in two or more marks for measurement on said mask, and said 1st reference mark to which it corresponds on said stage The reference mark to which it corresponds of said two or more 2nd reference marks by the alignment system of said off-axis method is observed. From the average of the amount of location gaps of two or more of said 2nd reference marks observed by the average of each amount of

location gaps of said two or more marks for measurement and said two or more 1st reference marks, and the alignment system of said off-axis method The projection exposure approach according to claim 2 characterized by asking for spacing of the reference point in the exposure field of said projection optical system, and the reference point of the alignment system of said off-axis method.

[Claim 4] Illuminate the lighting field of a predetermined configuration by the illumination light, and the pattern image on the mask in the lighting field of said predetermined configuration is exposed to the substrate on a stage through a projection optical system. By scanning said mask and said substrate synchronously relatively to the lighting field of said predetermined configuration In the approach of exposing the pattern image of an area larger than the lighting field of said predetermined configuration on said mask on said substrate Two or more marks for measurement are formed towards said relative scan on said mask. The reference mark member by which two or more reference marks were formed in these two or more marks for measurement and a location [ \*\*\*\* / almost ] is arranged on said stage. Said mask and said substrate are moved synchronizing with the direction of said relative scan. Sequential measurement of the amount of location gaps of one mark for measurement in two or more marks for measurement on said mask and the reference mark to which it corresponds on said stage is carried out. The 1st process which calculates each amount of location gaps of said mark for measurement and said reference mark; The amount of location gaps of one mark for measurement predetermined [ of two or more marks for measurement on said mask ] and the reference mark to which it corresponds on said stage is measured only once. The 2nd process which calculates the amount of location gaps of said mark for measurement and said reference mark; One of said 1st process and said 2nd process is chosen. The projection exposure approach characterized by having the 3rd process which asks for the response relation between the system of coordinates on said mask, and the system of coordinates on said stage based on each amount of location gaps of the mark for [ with which it asked at the selected process ] said measurement, and said reference mark, and;

[Claim 5] Illuminate the lighting field of a predetermined configuration by the illumination light, and the pattern image on the mask in the lighting field of said predetermined configuration is exposed to the substrate on a stage through a projection optical system. By scanning said mask and said substrate synchronously relatively to the lighting field of said predetermined configuration In the approach of exposing the pattern image of an area larger than the lighting field of said predetermined configuration on said mask on said substrate The alignment system of the off-axis method for detecting the location of the mark for positioning on said substrate near said projection optical system is arranged. Two or more marks for measurement are formed towards said relative scan on said mask. The reference mark member by which two or more reference marks were formed in these two or more marks for measurement and a location [ \*\*\*\* / almost ] is arranged on said stage. These two or more reference marks consist of the 1st and 2nd reference marks arranged at spacing corresponding to spacing of the reference point of said projection optical system, and the reference point of the alignment system of said off-axis method. Where said 2nd reference mark on said reference mark member is observed by the alignment system of said off-axis method Said mask is moved towards said relative scan. The 1st process which carries out sequential measurement of the amount of location gaps of one mark for measurement in two or more marks for measurement on said mask, and said 1st reference mark; where said 2nd reference mark on said reference mark member is observed by the alignment system of said off-axis method The 2nd process which measures the amount of location gaps of one predetermined mark for measurement in two or more marks for measurement on said mask, and said 1st reference mark; It is as a result of [ in the 3rd process which chooses one of said 1st process and said 2nd process, and the process chosen at the; this 3rd process ] measurement. From each amount of location gaps of said mark for measurement and said reference mark, and the amount of location gaps of said 2nd reference mark observed by the alignment system of said off-axis method The projection exposure approach characterized by having the 4th process which asks for spacing of the response relation between the system of coordinates on said mask, and the system of coordinates on said stage, and the reference point in the exposure field of said projection optical system and the reference point of the alignment system of said off-axis method, and;

[Claim 6] Illuminate the lighting field of a predetermined configuration by the illumination light, and the pattern image on the mask in the lighting field of said predetermined configuration is exposed to the substrate on a stage through a projection optical system. By scanning said mask and said substrate synchronously relatively to the lighting field of said predetermined configuration In the approach of exposing the pattern image of an area larger than the lighting field of said predetermined configuration on said mask on said substrate The alignment system of the off-axis method for detecting the location of the mark for positioning on said substrate near said projection optical system is arranged. Two or more marks

for measurement are formed towards said relative scan on said mask. The reference mark member by which two or more reference marks were formed in these two or more marks for measurement and a location [ \*\*\*\* / almost ] is arranged on said stage. These two or more reference marks consist of the 1st and 2nd reference marks formed at spacing corresponding to spacing of the reference point of said projection optical system, and the reference point of the alignment system of said off-axis method. Whenever it carries out predetermined number-of-sheets exchange of said substrate, where said 2nd reference mark on said reference mark member is observed by the alignment system of said off-axis method The amount of location gaps of one predetermined mark for measurement in two or more marks for measurement on said mask and said 1st corresponding reference mark is measured. From the measured this amount of location gaps, and the amount of location gaps of said 2nd reference mark observed by the alignment system of said off-axis method, the response relation between the system of coordinates on said mask, and the system of coordinates on said stage, The projection exposure approach characterized by asking for spacing of the reference point in the exposure field of said projection optical system, and the reference point of the alignment system of said off-axis method.

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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention is applied to the projection aligner of for example, a slit scan exposure method, and relates to the suitable projection exposure approach.

[0002]

[Description of the Prior Art] In case a semiconductor device, a liquid crystal display component, or the thin film magnetic head is manufactured at a photolithography process, the projection aligner which imprints a photo mask or the pattern of reticle (it is hereafter named "reticle" generically) on the substrates (a wafer, glass plate, etc.) with which it was applied to sensitization material is used. As a conventional projection aligner, each shot field of a wafer was moved into the exposure field of a projection optical system one by one, and many cutback projection mold aligners (stepper) of the step-and-repeat method of exposing the pattern image of reticle one by one to each shot field were used.

[0003] Drawing 18 shows the conventional stepper's important section, a wafer 5 is laid on the wafer stage 4 in this drawing 18, and the reference mark plate 57 is being fixed on the wafer stage 4 near this wafer 5. And projection exposure of the image of the pattern on reticle 12 is carried out to each shot field on a wafer 5 through a projection optical system 8 under the exposure light from the illumination-light study system by which the graphic display abbreviation was carried out. Under the present circumstances, since the wafer stage 4 is driven along with wafer system of coordinates, it is necessary to measure the angle of rotation over the location on the wafer system of coordinates of reticle 12, and the wafer system of coordinates of reticle 12. Therefore, two alignment marks (reticle mark) 60R and 61R are formed so that it may counter near the pattern space of reticle 12, and on the reference mark plate 57, two reference marks 60F and 61F are formed at spacing equal to spacing on the design on the wafer 5 of these reticle marks 60R and 61R.

[0004] Moreover, on the reticle marks 60R and 61R of reticle 12, the reticle alignment microscopes 58 and 59 are arranged, respectively. The reticle alignment microscopes 58 and 59 are equipped with the sensor which can observe simultaneously the source of the illumination light which injects the alignment light of the same wavelength as exposure light, respectively, the reticle mark on reticle 12, the alignment mark on a wafer 5 (wafer mark), or the reference mark on the reference mark plate 57. In case exposure to a wafer 5 is performed by the stepper of drawing 18, the image of the pattern on reticle 12 is exposed by each shot field of a wafer 5, respectively by moving by the step-and-repeat method one by one only on the wafer stage 4.

[0005] In this stepper, in exposing the pattern image of reticle 12 further on the circuit pattern on the wafer 5 formed at the before process, there is the need of taking a response with the wafer system of coordinates which specify the coordinate of each shot field on a wafer 5, and the Reticulum label system which specifies the coordinate of the pattern on reticle 12 (that is, alignment being performed). In the case of the stepper, the one-shot area size on the exposure field of a projection optical system 8 and a wafer 5 was equal, and since it was not necessary to drive reticle 12 in case it exposes, the response of wafer system of coordinates and a Reticulum label system had been taken as follows.

[0006] That is, after driving the wafer stage 4 and moving the reference mark plate 57 into the exposure field of a projection optical system 8, one reticle alignment microscope 58 detected the amount of location gaps of reticle mark 60R and reference mark 60F, under the reticle alignment microscope 59 of another side, the amount of location gaps of reticle mark 61R and reference mark 61F was detected, and the location of the pattern of the reticle 12 on wafer system of coordinates was calculated from the amount of these locations gaps. Furthermore, the angle of rotation of the reticle 12 on wafer system of coordinates was measured by moving reference mark 60F to the location of reference mark 61F, and detecting the amount of location gaps of reticle mark 61R and reference mark 60F under the reticle alignment microscope 59. And

matching with wafer system of coordinates and a Reticulum label system was eventually performed by rotating reticle 12 or the wafer stage 4, and amending the angle of rotation.

[0007] Moreover, in drawing 18, in order to detect the location of each alignment mark (wafer mark) formed corresponding to each shot field on a wafer 5, the alignment microscope 34 of an off-axis method is formed in the lateral portion of a projection optical system 8. In this case, based on the location of the wafer mark detected under this alignment microscope 34, the shot field on the corresponding wafer 5 is set up in the exposure field of a projection optical system 8. Therefore, it is necessary to calculate the so-called amount of base lines which is spacing of the reference point in the exposure field of a projection optical system 8 (for example, exposure core), and the reference point 62 of the observation field of the alignment microscope 34 of an off-axis method beforehand.

[0008] In the conventional stepper, when measuring such an amount of base lines, after measuring the amount of location gaps with the conjugate image of the reticle marks 60R and 61R and reference marks 60F and 61F, only the amount equal to the design value of the amount of base lines moved the wafer stage 4, and was measuring the amount of location gaps with the reference mark to which it corresponds on the reference point 62 and reference mark plate 57 under the alignment microscope 34. The amount of base lines was calculated from those amounts of location gaps.

[0009]

[Problem(s) to be Solved by the Invention] Since the pattern has made it detailed in a semiconductor device etc. in recent years, heightening the resolution of a projection optical system is called for. Although there is technique, such as short-wavelength-izing of the wavelength of exposure light or buildup of the numerical aperture of a projection optical system, among the technique for heightening resolution, if it is going to secure the exposure field of same extent as the conventional example even when using which technique, it will become difficult to maintain image formation engine performance (distortion, curvature of field, etc.) for a predetermined precision all over the exposure field. Then, the so-called projection aligner of a slit scan exposure method is improved now.

[0010] In the projection aligner of this slit scan exposure method, the pattern of that reticle is exposed on a wafer, synchronizing relatively and scanning reticle and a wafer to the shape of a rectangle, and the lighting field (henceforth a "slit-like lighting field") of circular \*\*. Therefore, if the pattern of the same area as a stepper method is exposed on a wafer, by the slit scan exposure method, compared with a stepper method, the exposure field of a projection optical system can be made small, and the precision of the image formation engine performance in the exposure field may improve.

[0011] Although the mainstream of the magnitude of the conventional reticle was 6 inch size and the mainstream of the projection scale factor of a projection optical system was 1/5 time, the magnitude of the reticle in a basis 1/5 time the scale factor of this has stopped moreover, 6 inch size being of use with large area-ization of circuit patterns, such as a semiconductor device. Therefore, it is necessary to design the projection aligner which changed the projection scale factor of a projection optical system 1/4 time. And also in order to respond to large area-ization of such a transferred pattern, a slit scan exposure method is advantageous.

[0012] In the projection aligner of this slit scan exposure method, when the technique of matching with the Reticulum label system and wafer system of coordinates which were used by the conventional stepper is applied, since the projection scale factor increased 1/4 time, there is inconvenience that alignment precision deteriorates according to the drawing error of the circuit pattern on reticle. Furthermore, in Japanese Patent Application No. No. 169781 [ three to ], the technique which resembles measuring simultaneously the amount of location gaps of two or more marks for measurement, and measures the angle of rotation of reticle more is proposed, without moving a wafer stage in a stepper. However, the concept of measurement of the angle of rotation by simultaneous measurement of two or more of these marks for measurement could not be used for the scanning direction of the projection aligner of a slit scan exposure method, but there was inconvenience that the angle of rotation of a Reticulum label system and wafer system of coordinates and coordinate perpendicularity of these system of coordinates could not measure with a sufficient precision in it.

[0013] Moreover, by having applied the measurement approach using one mark (two pieces) on the reticle in the conventional stepper to the projection aligner of a slit scan exposure method as it was, there is inconvenience of being greatly influenced of the drawing error of reticle, about the measurement approach of the amount of base lines which is spacing of the criteria location in the exposure field of a projection optical system, and the criteria location of the alignment system of an off-axis method.

[0014] In view of this point, in the projection aligner of a slit scan exposure method, this invention reduces

the effect of the drawing error of the pattern on reticle (mask), and aims at offering the projection exposure approach that matching with a Reticulum label system (mask system of coordinates) and wafer system of coordinates (substrate system of coordinates) can be performed to accuracy. Depending on [ accuracy / of the matching ] a process, quick nature may be thought as important about this. Then, this invention aims at offering the projection exposure approach of performing matching with a Reticulum label system (mask system of coordinates) and wafer system of coordinates (substrate system of coordinates) by the high throughput.

[0015] Furthermore, in the projection aligner of a slit scan exposure method, this invention reduces the effect of the drawing error of the pattern on reticle (mask), and aims also at offering the projection exposure approach which can measure the amount of base lines which is spacing of the origin/datum of the exposure field of a projection optical system, and the origin/datum of the alignment system of an off-axis method to high degree of accuracy.

[0016] Moreover, whenever it exchanges the wafer of predetermined number of sheets, when performing base-line measurement, for example, while greater importance may be attached than to correctness to quick nature, it is desirable to perform matching with a Reticulum label system (mask system of coordinates) and wafer system of coordinates (substrate system of coordinates) simultaneously. Then, in case this invention measures the amount of base lines for every predetermined wafer turnover rate, it aims at offering the projection exposure approach of performing matching with a Reticulum label system (mask system of coordinates) and wafer system of coordinates (substrate system of coordinates), and its base-line measurement by the high throughput.

[0017]

[Means for Solving the Problem] The 1st projection exposure approach by this invention illuminates the lighting field of a predetermined configuration by the illumination light. The pattern image on the mask in the lighting field of said predetermined configuration (12) is exposed to the substrate (5) on a stage (4) through a projection optical system (8). By scanning a mask (12) and a substrate (5) synchronously relatively to the lighting field of the predetermined configuration In the approach of exposing the pattern image of an area larger than the lighting field of the predetermined configuration on a mask (12) on a substrate (5) Two or more marks for measurement (29A-29D) are formed towards the relative scan on a mask (12). The reference mark member (6) by which two or more reference marks (35A-35D) were formed in the mark for measurement of these plurality and the location [ \*\*\*\* / almost ] is arranged on a stage (4). A mask (12) and a substrate (5) are moved synchronizing with the direction of the relative scan. Sequential measurement of the amount of location gaps with the reference mark (35A, 35B, ..) to which it corresponds on one mark for measurement in a mark (29A, 29B, ....) and stage (4) for measurement of the plurality on a mask (12) is carried out. It asks for the response relation between the system of coordinates on a mask (12), and the system of coordinates on a stage (4) from each amount of location gaps of the mark for measurement of these plurality, and the reference mark of these plurality.

[0018] Moreover, the 2nd projection exposure approach by this invention is set in the same premise section as above-mentioned invention. The alignment system (34) of the off-axis method for detecting the location of the mark for positioning on a substrate (5) near the projection optical system (8) is arranged. Two or more marks for measurement (29A-29D) are formed towards the relative scan on a mask (12). The reference mark member (6) in which the 1st reference mark (35A) and 2nd reference mark (37A) were formed at spacing corresponding to spacing of the reference point in the exposure field of a projection optical system (8) and the reference point of the alignment system (34) of an off-axis method is arranged on a stage (4).

[0019] And where the 2nd reference mark (37A) on a criteria member (6) is observed by the alignment system (34) of an off-axis method Move a mask (12) towards said relative scan, and sequential measurement of the amount of location gaps with the 1st reference mark (35A) on one mark for measurement in a mark (29A, 29B, ....) and stage (4) for measurement of the plurality on a mask (12) is carried out. From the amount of location gaps of the 2nd reference mark observed by the average of each amount of location gaps of the mark for measurement of these plurality, and these 1st reference marks, and the alignment system (34) of an off-axis method It asks for spacing of the reference point in the exposure field of a projection optical system (8), and the reference point of the alignment system (34) of an off-axis method.

[0020] Moreover, the 3rd projection exposure approach of this invention is set to the 2nd projection exposure approach. While making two or more marks for measurement (29A-29D) on a mask (12) correspond on a reference mark member (6) and forming two or more (35A-35D) the 1st reference mark Two or more (37A-37D) the 2nd reference mark is formed [ from the 1st reference mark (35A-35D) of these plurality ] at spacing corresponding to spacing of the reference point in the exposure field of a projection



optical system (8), and the reference point of the alignment system (34) of an off-axis method, respectively. A mask (12) and a stage (4) are moved synchronizing with the direction of the relative scan. While carrying out sequential measurement of the amount of location gaps with the 1st reference mark (35A, 35B, ...) to which it corresponds on one mark for measurement in a mark (29A, 29B, ...) and stage (4) for measurement of the plurality on a mask (12) The reference mark (37A, 37B, ...) to which it corresponds of two or more 2nd reference marks by the alignment system (34) of an off-axis method is observed. From the average of the amount of location gaps of the 2nd reference mark of these plurality observed by the average of each amount of location gaps of the mark for measurement of these plurality, and the 1st reference mark of these plurality, and the alignment system (34) of an off-axis method It asks for spacing of the reference point in the exposure field of a projection optical system (8), and the reference point of the alignment system (34) of an off-axis method.

[0021] Next, the 4th projection exposure approach of this invention is set in the same premise section as above-mentioned invention. Like the 1st above-mentioned projection exposure approach A mask (12) Two or more upper marks for measurement (29A, 29B, --), and a corresponding reference mark The 1st process which calculates each amount of location gaps with (35A, 35B, --); The amount of location gaps of one mark for measurement predetermined [ of two or more marks for measurement on the mask ] (29A) and the reference mark (35A) to which it corresponds on the stage is measured only once. The 2nd process which calculates the amount of location gaps of the mark for measurement (29A), and a reference mark (35A) in simple; One of the 1st process and its 2nd process is chosen. It has the 3rd process and; which ask for the response relation between the system of coordinates on a mask (12), and the system of coordinates on a stage (4) based on each amount of location gaps of the mark for [ with which it asked at this selected process ] that measurement, and its reference mark.

[0022] Moreover, the 5th projection exposure approach of this invention is set in the same premise section as above-mentioned invention. Like the 2nd above-mentioned projection exposure approach, where the 2nd reference mark (37A, 37B, --) on a reference mark member (6) is observed by the alignment system of an off-axis method A mask (12) is moved towards the relative scan. A mask (12) Two or more upper marks for measurement Where the 2nd reference mark (37A) on a reference mark member (6) is observed by the alignment system of the 1st process and; off-axis method which carries out sequential measurement of the amount of location gaps of one mark for measurement in (29A, 29B, --), and the 1st reference mark (35A, 35B, --) A mask ; (12) -- the 2nd process which measures the amount of location gaps of one predetermined mark for measurement in two or more upper marks for measurement (29A), and the 1st reference mark (35A) in simple, and; -- with the 3rd process which chooses one of these 1st processes and the 2nd process The amount of location gaps of the mark for [ which it is as a result of / in the process chosen at this 3rd process / measurement ] that measurement, and its reference mark, From the amount of location gaps of the 2nd reference mark observed by the alignment system of the off-axis method, and the response relation between the system of coordinates on the mask, and the system of coordinates on the stage, It has the 4th process and; which ask for spacing (the amount of base lines) of the origin/datum in the exposure field of the projection optical system, and the origin/datum of the alignment system of the off-axis method.

[0023] Moreover, the 6th projection exposure approach of this invention is set in the same premise section as above-mentioned invention. The alignment system (34) of the off-axis method for detecting the location of the mark for positioning on a substrate (5) near the projection optical system (8) is arranged. Two or more marks for measurement (29A, 29B, --) are formed towards the relative scan on a mask (12). The reference mark member (6) by which two or more reference marks were formed in the mark for measurement of these plurality and the location [ \*\*\*\* / almost ] is arranged on a stage (4). Whenever the reference mark of these plurality consists of the 1st (A [ 35 ], B [ 35 ], --) and 2nd (A [ 37 ], B [ 37 ], --) reference marks formed at spacing corresponding to spacing of the reference point of the projection optical system, and the reference point of the alignment system of the off-axis method and it carries out predetermined number-of-sheets exchange of the substrate (5) Where the 2nd reference mark (37A) on a reference mark member (6) is observed by the alignment system of the off-axis method The amount of location gaps of one predetermined mark for measurement (29A) in two or more marks for measurement on a mask (12) and the 1st corresponding reference mark (35A) is measured. From the measured amount of location gaps, and the amount of location gaps of the 2nd reference mark (37A) observed by the alignment system of the off-axis method, thus, the response relation between the system of coordinates on the mask, and the system of coordinates on the stage, It asks for spacing (the amount of base lines) of the origin/datum in the exposure field of the projection optical system, and the origin/datum of the alignment system of the off-axis method.

[0024]



[Function] In the 1st projection exposure approach of this invention, two or more marks for measurement are arranged on a mask (12), those marks for measurement and a reference mark [ \*\*\*\* / almost ] are arranged on a reference mark member (6), and a location gap of each mark is measured with delivery by the stepping method in a mask (12) and a stage (4). And according to the location gap called for in each location, the effect of the drawing error of the mark for measurement on a mask (12) can be eventually suppressed small by asking for the parameter (offset of a scale factor, the scaling of a scanning direction, a revolution, the parallelism of a scanning direction, the direction of X, and the direction of Y) which matches mask system of coordinates and substrate system of coordinates by the least squares approximation etc. Moreover, since mark measurement of the direction of a relative scan is performed independently one by one, it turns into un-simultaneous measurement, but since it measures by two or more places, it has the equalization effectiveness and the high-degree-of-accuracy measurement of it is attained.

[0025] Moreover, according to the 2nd projection exposure approach, by equalizing the measurement result about two or more marks for measurement by the side of a mask (12), effect of the drawing error of the mark for measurement of a mask (12) is made small, and the amount of base lines which is spacing of the origin/datum of a projection optical system (8) and the origin/datum of an alignment system (34) can be measured to accuracy. Moreover, while according to the 3rd projection exposure approach making two or more marks for measurement (29A-29D) on a mask (12) correspond on a reference mark member (6) and forming two or more (35A-35D) the 1st reference mark Since two or more (37A-37D) the 2nd reference mark is formed [ from the 1st reference mark (35A-35D) of these plurality ] at spacing corresponding to spacing of the reference point in the exposure field of a projection optical system (8), and the reference point of the alignment system (34) of an off-axis method, respectively, Since equalization is performed also for a reference mark side, the amount of base lines is measured more by accuracy.

[0026] Next, according to the 4th projection exposure approach of this invention, when the 2nd process is chosen, the amount of location gaps of the mark for measurement (29A) and a reference mark (35A) is measured only once, when a high throughput is required, and high degree of accuracy is required, the demand to quick nature can also be filled by performing the 1st process. In this case, in the 1st process, when it memorizes in quest of the amount of location gaps (this is called a "mark error") from the original location of the mark for measurement (29A) further beforehand and the 2nd process is performed, the demand of both high throughputs and high degree of accuracy can be met by amending that mark error.

[0027] Similarly, when a high throughput is required according to the 5th projection exposure approach Where it chose the 2nd process and the 2nd reference mark (37A) is observed by the alignment system (34) When the amount of location gaps of one mark for measurement (29A) and the 1st reference mark (35A) is measured only once and high degree of accuracy is required, the demand to quick nature can also be filled by performing the 1st process. In this case, in the 1st process, when it memorizes in quest of the mark error further beforehand and the 2nd process is performed, the demand of both high throughputs and high degree of accuracy can be met by amending that mark error.

[0028] Moreover, whenever it carries out predetermined number-of-sheets exchange of the substrate (5) according to the 6th projection exposure approach (i.e., whenever it exposes to the substrate (5) of predetermined number of sheets), where the 2nd reference mark (37A) is observed by the alignment system (34) of an off-axis method The amount of location gaps of one mark for measurement (29A) and the 1st reference mark (35A) is measured only once, and the response relation and the amount of base lines of the system of coordinates on a mask and the system of coordinates on a stage are calculated from this measurement result. Therefore, measurement is performed by the high throughput.

[0029]

[Example] Hereafter, with reference to a drawing, it explains per 1st example of the projection exposure approach by this invention. This example applies this invention, when exposing the pattern of reticle on a wafer with the projection aligner of a slit scan exposure method. Drawing 1 shows the projection aligner of this example, the pattern on reticle 12 is illuminated by the lighting field (henceforth a "slit-like lighting field") of the rectangle by the exposure light EL from the illumination-light study system by which the graphic display abbreviation was carried out in this drawing 1 , and projection exposure of the image of that pattern is carried out on a wafer 5 through a projection optical system 8. In this case, synchronizing with reticle 12 being scanned with constant speed V forward to the space of drawing 1 , a wafer 5 is scanned backward to the space of drawing 1 to the lighting field of the shape of a slit of the exposure light EL by constant speed V/M (1/M is the cutback scale factor of a projection optical system 8).

[0030] The reticle Y actuation stage 10 which can be freely driven to Y shaft orientations (direction vertical to the space of drawing 1 ) on the reticle susceptor 9 is laid by explaining the drive system of reticle 12 and

a wafer 5, the reticle minute actuation stage 11 is laid on this reticle Y actuation stage 10, and reticle 12 is held by the vacuum chuck etc. on the reticle minute actuation stage 11. As for the reticle minute actuation stage 11, only a minute amount carries out position control of reticle 12 to high degree of accuracy in a field vertical to the optical axis of a projection optical system 8 in the direction of X parallel to space, the direction of Y, and hand of cut (the direction of theta) of drawing 1, respectively. It always acts as the monitor of the location of the direction of X of the reticle minute actuation stage 11, the direction of Y, and the direction of theta with the interferometer 14 which the migration mirror 21 has been arranged on the reticle minute actuation stage 11, and has been arranged on the reticle susceptor 9. The positional information S1 acquired by the interferometer 14 is supplied to main control system 22A.

[0031] On the other hand on the wafer susceptor 1, the wafer Y-axis actuation stage 2 which can be freely driven to Y shaft orientations is laid, the wafer X-axis actuation stage 3 which can be freely driven to X shaft orientations is laid on it, Ztheta shaft actuation stage 4 is formed on it, and the wafer 5 is held by vacuum adsorption on this Ztheta shaft actuation stage 4. The migration mirror 7 is fixed also on Ztheta shaft actuation stage 4, it acts as the monitor of the location of the direction of X of Ztheta shaft actuation stage 4, the direction of Y, and the direction of theta with the interferometer 13 arranged outside, and the positional information acquired by the interferometer 13 is also supplied to main control system 22A. Main control system 22A controls actuation of the whole equipment while controlling positioning actuation of the wafer Y-axis actuation stage 2, the wafer X-axis actuation stage 3, and Ztheta shaft actuation stage 4 through wafer driving gear 22B etc.

[0032] Moreover, although mentioned later, in order to take the response of the wafer system of coordinates specified by the coordinate measured by the interferometer 13 by the side of a wafer, and the Reticulum label system specified by the coordinate measured by the interferometer 14 by the side of reticle, the reference mark plate 6 is being fixed near the wafer 5 on Ztheta shaft actuation stage 4. On this reference mark plate 6, various reference marks are formed like the after-mentioned. The reference mark currently illuminated from the background by the illumination light led to Ztheta shaft actuation stage 4 side, i.e., a luminescent reference mark, is in these reference marks.

[0033] The reticle alignment microscopes 19 and 20 for observing simultaneously the reference mark on the reference mark plate 6 and the mark on reticle 12 are equipped above the reticle 12 of this example. In this case, if deflection Miller 15 and 16 for leading the detection light from reticle 12 to the reticle alignment microscopes 19 and 20, respectively is stationed free [ migration ] and an exposure sequence is started, deflection Miller 15 and 16 will be evacuated by the Miller driving gears 17 and 18 under the command from main control system 22A, respectively. Furthermore, the alignment equipment 34 of the off-axis method for observing the alignment mark on a wafer 5 (wafer mark) to the lateral portion of the direction of Y of a projection optical system 8 is arranged.

[0034] Moreover, keyboard 22C for inputting the command from an operator is connected to main control system 22A. There is quick mode for measuring the amount of base lines etc. in simple like the after-mentioned other than the mode which measures to high degree of accuracy in the projection aligner of this example, and the mode which an operator performs to main control system 22A through keyboard 22C after this directs high-degree-of-accuracy mode or quick mode.

[0035] Next, in the projection aligner of this example, it explains with reference to the flow chart of drawing 2 per sequence after loading a wafer 5 and reticle 12 until it ends alignment. In step 101 of drawing 2, PURIARAIMENTO of reticle 12 is first performed on appearance criteria on a reticle loader (after-mentioned). Drawing 3 shows the reticle loader system for conveying reticle 12 on the reticle minute actuation stage 11 of drawing 1, and the reticle loader of this drawing 3 consists of two reticle arms 23A and 23B, an arm revolving shaft 25 connected with these reticle arms 23A and 23B, and a rolling mechanism 26 which rotates this arm revolving shaft 25. The slots 24A and 24B for vacuum adsorption are formed in the reticle installation side of the reticle arms 23A and 23B, respectively, and the reticle arms 23A and 23B are supported so that it can rotate independently through the arm revolving shaft 25, respectively.

[0036] At the time of loading of reticle 12, reticle 12 is received and passed on reticle arm 23A from other reticle conveyance devices (un-illustrating) by location A3. In this case, reticle arm 23B of another side is used for taking out of the reticle used for example, at the before process. Next, after alignment of the reticle 12 is carried out to a fixed precision on appearance criteria on reticle arm 23A by the reticle appearance PURIARAIMENTO device (un-illustrating) installed near location A3, vacuum adsorption of the reticle 12 is carried out on reticle arm 23A by it. Next, in step 102 of drawing 2, a rolling mechanism 26 rotates reticle arm 23A through the arm revolving shaft 25, and moves reticle 12 to the location B3 of the direction (position in readiness of the reticle actuation stage 10 of drawing 1 (delivery location)) of Y.

[0037] At this time, slot 24A for vacuum adsorption is the direction which intersected perpendicularly with the adsorption location on the reticle minute actuation stage 11, and it is in the condition which moved to the tip of the direction of y whose reticle minute actuation stage 11 is a scanning direction since it was in the location besides the pattern space of reticle 12, and reticle arm 23A can take reticle 12 now in and out of on the reticle minute actuation stage 11 freely. If reticle 12 reaches on the reticle minute actuation stage 11 (refer to drawing 1 ), it will fall in - Z direction, reticle 12 will be laid in the vacuum adsorption side on the reticle minute actuation stage 11, and reticle arm 23A will evacuate the arm revolving shaft 25 after the completion of delivery of reticle 12. Then, the reticle minute actuation stage 11 conveys reticle 12 in the location C3 direction, and goes to it. In this case, the reticle arms 23A and 23B are that drive independently, for example, each performs a reticle load and a reticle unload simultaneously, and the reticle rate of exchange is improving.

[0038] Next, although alignment of reticle 12 is performed at 103 or less step of drawing 2 , it explains per the device for it, and actuation. Drawing 4 (a) shows arrangement of the alignment mark on reticle 12 (reticle mark), and drawing 4 (b) shows the slit-like lighting \*\*\*\*\* 32 grade within the effective exposure field of a projection optical system, and field 33R [ \*\*\*\* ] on reticle. A direction vertical to the direction of y is made into x directions by making a scanning direction into the direction of y. In drawing 4 (a), the reticle mark which the protection-from-light section 31 is formed in the perimeter of the pattern space of the center section on reticle 12, and is formed in the outside of this protection-from-light section 31 is divided into the fine alignment marks 29A-29D, and 30A-30D. [ the alignment marks 27 and 28 for a rough search, and ] The alignment mark 27 for a rough search by the side of the right-hand side is formed along the direction of y which is a scanning direction from a long straight-line-like pattern and the cross-joint pattern formed in the both ends of this straight-line-like pattern, and the alignment mark 28 for a rough search by the side of left part is constituted as symmetrically as the alignment mark 27 for a rough search by the side of the right-hand side.

[0039] Moreover, between the protection-from-light section 31 by the side of the right-hand side, and one cross-joint pattern of the alignment mark 27 for a rough search, it approaches in the direction of y and the fine alignment marks 29A and 29B are formed, between the protection-from-light section 31 by the side of the right-hand side, and the cross-joint pattern of another side of the alignment mark 27 for a rough search, it approaches in the direction of y and the fine alignment marks 29C and 29D are formed. The fine alignment marks 30A-30D are formed in these fine alignment marks 29A-29D and a symmetrical target at the left part side. These fine alignment marks 29A-29D, and 30A-30D In drawing 4 (a), while arranging 2 sets of three straight-lines-like patterns at intervals of predetermined in the x directions as actually shown in drawing 4 (c), respectively although only shown as a cross-joint-like mark, 2 sets of three straight-lines-like patterns are arranged at intervals of predetermined in the direction of y.

[0040] In step 103 of drawing 2 , the reticle alignment microscope (henceforth "RA microscope") 20 of drawing 1 detects the alignment mark 28 for a rough search by the side of the left part of drawing 4 (a) first. In case drawing 4 (b) shows the observation fields 19R and 20R on the reticle 12 of the RA microscopes 19 and 20 in this case and performs a rough search, the alignment marks 27 and 28 for a rough search are outsides [ fields / 19R and 20R / observation ], respectively, and it is the effective exposure field and outside field 33R [ \*\*\*\* ]. Although this needs to enlarge the alignment marks 27 and 28 for a rough search for a rough search, when the exposure field of a projection optical system is enlarged according to it, it is because it is necessary to enlarge the diameter of a projection lens and becomes a cost rise. Then, this example explains with reference to drawing 5 per procedure at the time of performing a rough search.

[0041] It is drawing where drawing 5 (a) reduced the enlarged drawing near [ one ] the cross-joint pattern of the alignment mark 28 for a rough search, and drawing 5 (b) reduced drawing 5 (a), and in this drawing 5 (a) and (b), the design value of the sum of the drawing error of a pattern and installation error over the appearance of reticle 12 is set to  $\Delta R$ , using width of face of validity visual field 20Ref of the square of the RA microscope 20 as W. Therefore, as shown in drawing 5 (b), one cross-joint pattern 28a of the alignment mark 28 for a rough search is surely contained in the field of the square of width-of-face  $\Delta R$ . Although the object for detection is the x-coordinate and y-coordinate of the cross-joint pattern 28a, in this example, validity visual field 20Ref of the width of face W is aslant scanned in the direction which crosses at 45 degrees to biaxial [ of the alignment mark 28 ], i.e., a x axis and the y-axis. And it asks for the x-coordinate and y-coordinate of the cross-joint pattern 28a as the x-coordinate and y-coordinate when crossing the alignment mark 28 on the occasion of the inclining scan.

[0042] For that purpose, the number of search screens which is the minimum count which scans the field of the square of the width-of-face  $\Delta R$  by validity visual field 20Ref of the width of face W as what

expresses the integer part of the forward real number  $a$  with  $\text{INT}(a)$  is set to  $\{\text{INT}(\Delta R/W)+1\}$ . It asks for this number of search screens beforehand. And to the field of the square of the width-of-face  $\Delta R$  centering on the first effective visual field B5, set up effective visual field A5 of the  $\{\text{INT}(\Delta R/W)+1\}$  individual of width of face  $W$ , B5, C5, and .... aslant, respectively, and the reticle minute actuation stage 11 of drawing 1 is driven. The image within each effective visual field is sampled carrying out stepping of each effective visual field, and setting up in effective visual field 20Ref of drawing 5 (a) one by one.

[0043] As shown in drawing 5 (b), at least, cross-joint pattern 28a of the alignment mark 28 for a search exists all over the search range of width-of-face  $\Delta R$ , and the alignment mark 28 is fully large to the search range. Therefore, if step feed of the effective visual field is carried out in the direction of slant to this alignment mark 28, it turns out with the minimum number of screens that the coordinate of cross-joint pattern 28a of the alignment mark 28 is detectable. The image processing at that time is good at the single dimension image processing to the picture signal which adds the scanning line of all the lines in the picturized screen, and is acquired.

[0044] The various picture signals which drawing 6 added the scanning line of all lines such, and were acquired are shown. The picture signal which meets in  $x$  directions and the direction of  $y$  in which drawing 6 (a) and (d) are obtained in effective visual field A5 of drawing 5 (b), The picture signal which meets in  $x$  directions and the direction of  $y$  in which drawing 6 (b) and (e) are obtained in effective visual field B5 of drawing 5 (b), drawing 6 (c), and (f) are picture signals which meet in  $x$  directions and the direction of  $y$  which are acquired with the effective visual field C5 of drawing 5 (b). The  $x$ -coordinate of cross-joint pattern 28a is called for from the picture signal of drawing 6 (b), and the  $y$ -coordinate of cross-joint pattern 28a is called for from the picture signal of drawing 6 (f).

[0045] Thus, after detecting the reticle mark 28 for a search, in step 104 of drawing 2, the alignment mark 27 for a rough search is moved to the observation field of the RA microscope 19, and the location of that alignment mark 27 is detected similarly shortly. However, the part which does not have the pattern of the reference mark plate 6 of drawing 1 in this case is moved into the exposure field of a projection optical system 8, and the part without that pattern is illuminated from the pars basilaris ossis occipitalis. Thus, by the illumination light injected from the reference mark plate 6, the alignment marks 27 and 28 for these rough searches are illuminated from a rear-face side.

[0046] By the above sequence, the location of the alignment marks 27 and 28 for a rough search to the observation fields 19R and 20R of the RA microscopes 19 and 20 of drawing 4 (b) and the response of a Reticulum label system can be attached roughly. Moreover, rough matching with the observation fields 19R and 20R of RA microscope and wafer system of coordinates can be performed by measuring the reference mark on the reference mark plate 6 of drawing 1 under the RA microscopes 19 and 20. Thereby, the rough alignment (rough alignment) which is extent with which the fine alignment marks 29A-29D and 30A-30D, and the reference mark on the reference mark plate 6 (after-mentioned) do not lap is completed.

[0047] However, in this example, in order to make small the diameter of a lens of a projection optical system 8, the alignment mark on reticle 12 is divided into the alignment mark for a rough search, and the fine alignment mark, but when the diameter of a lens of a projection optical system 8 may be enlarged, the alignment mark for these rough searches and a fine alignment mark can be carried out to a common mark. Even in this case, as shown in drawing 5, the technique of carrying out step feed in the direction of slant, and searching an alignment mark can be diverted, and can also search an alignment mark simultaneously under the RA microscopes 19 and 20.

[0048] Next, although the sequence of fine alignment is explained, it explains per detailed configuration of a wafer stage and a reticle stage before that. Drawing 7 (a) is the top view of a wafer stage, and the wafer 5 and the reference mark plate 6 are arranged on Ztheta shaft actuation stage 4 in this drawing 7 (a).

Moreover, on Ztheta shaft actuation stage 4, migration mirror 7X for the X-axes and migration mirror 7Y for Y-axes are fixed, lighting field 32W of the shape of a slit corresponding to the lighting field 32 of the shape of a slit of drawing 4 (b) are illuminated with exposure light on a wafer 5, and the observation fields 19W and 20W are the observation fields 19R and 20R of drawing 4 (b), and conjugation, respectively.

[0049] It is parallel to the X-axis, and the laser beam LWX and LWof of spacing IL are irradiated by migration mirror 7X in accordance with the optical path which passes along the optical axis of a projection optical system, and the origin/datum of alignment equipment 34, respectively, and two laser beams LWY1 and LWY2 of spacing IL are irradiated in accordance with the optical path parallel to a Y-axis at migration mirror 7Y. Coordinate value Y1 which the coordinate value measured as an X coordinate of Ztheta shaft actuation stage 4 with the interferometer which uses a laser beam LWX was used at the time of exposure, and was measured with the interferometer using laser beams LWY1 and LWY2 as a Y coordinate,

respectively And Y2 The average  $(Y1+Y2)/2$  are used. Moreover, coordinate value Y1 Y2 The rotation of the hand of cut (the direction of theta) of Ztheta shaft actuation stage 4 is measured from difference. Based on those coordinates, the location and angle of rotation of XY flat surface of Ztheta shaft actuation stage 4 are controlled.

[0050] Especially the direction of Y that is a scanning direction is using the average of the measurement result of two interferometers, and is easing the error by the air fluctuation at the time of a scan etc. according to the equalization effectiveness. Moreover, the location of X shaft orientations in the case of using the alignment equipment 34 of an off-axis method is a configuration controlled based on the measurement value of the exclusive interferometer which uses a laser beam LWof like which the so-called Abbe error does not produce.

[0051] Drawing 7 (b) is the top view of a reticle stage, in this drawing 7 (b), the reticle minute actuation stage 11 is laid on the reticle Y actuation stage 10, and reticle 12 is held on it. Moreover, two migration mirrors 21y1 for migration mirror 21x and the y-axes for x axes and 21y2 are fixed to the reticle minute actuation stage 11, a laser beam LRx is irradiated by parallel in a x axis migration mirror 21x, and laser beams LRy1 and LRy2 are irradiated [ the migration mirror 21y1 and 21y2 ] by parallel at the y-axis, respectively.

[0052] The coordinate of the direction of y of the reticle minute actuation stage 11 is the coordinate value y1 measured with two interferometers which use laser beams LRy1 and LRy2 like a wafer stage. And y2 The average  $(y1+y2)/2$  are used. Moreover, the coordinate value measured with the interferometer with which a laser beam LRx is used for the coordinate of x directions is used. Moreover, coordinate value y1 y2 The rotation of the hand of cut (the direction of theta) of the reticle minute actuation stage 11 is measured from difference.

[0053] In this case, the reflective element of a corner cube mold is used as the migration mirror 21y1 of the direction of y which is a scanning direction, and 21y2, and the migration mirror 21y1 and the laser beams LRy1 and LRy2 reflected by 21y2 are reflected and returned by reflective Miller 39 and 38, respectively. That is, the interferometer for the reticles is a double pass interferometer, and has composition which a location gap of a laser beam does not produce by revolution of the reticle minute actuation stage 11 by this. Moreover, the slit-like lighting field 32 and the observation fields 19R and 20R of the RA microscopes 19 and 20 are arranged on reticle 12 like the wafer stage top. And Ztheta shaft actuation stage 4 of reticle 12 and drawing 7 (a) can be observed now only from the observation fields 19R and 20R. Thus, although it is the translation which measures the relation between reticle 12 and Ztheta shaft actuation stage 4, and raises the alignment precision at the time of exposure, and the rotational accuracy of reticle 12 and a wafer 5, with reference to drawing 8 and drawing 9, it explains per that approach.

[0054] Reticle image 12W which drawing 8 (a) projects the reticle 12 of drawing 4 (a) on the reference mark plate 6 of drawing 7 (a), and are obtained are shown, and mark image 29AW-29DW [ \*\*\*\* ] and mark image 30AW-30DW [ \*\*\*\* / the fine alignment marks 30A-30D ] are shown in the fine alignment marks 29A-29D of drawing 4 (a) in this drawing 8 (a). each -- mark image 29AW-29DW and 30AW-30DW are configurations which have arranged the three straight-lines-like pattern to four sides, as shown in drawing 8 (b), respectively.

[0055] Drawing 8 (c) shows arrangement of the reference mark on the reference mark plate 6, and reference marks 35A-35D, and 36A-36D are formed on the reference mark plate 6 of this drawing 8 (c), respectively by the almost same arrangement as mark image 29AW-29DW of drawing 8 (a), and 30AW-30DW. These reference marks are illuminated by the illumination light of the same wavelength as exposure light from the rear face of the reference mark plate 6. Moreover, reference mark 37A is formed in the location which separated only spacing IL from the middle point of reference marks 35A and 36A on the reference mark plate 6 in the direction of Y which is a scanning direction. Spacing IL is equal to the amount of base lines which is spacing of the origin/datum of a projection optical system 8 and the origin/datum of the alignment equipment 34 of an off-axis method in drawing 1. Similarly, reference marks 37B, 37C, and 37D are formed in the location where only spacing IL separated from the middle point of reference marks 35B and 36B, the middle point of reference marks 35C and 36C, and the middle point of reference marks 35D and 36D in the direction of Y, respectively.

[0056] Consisting of [ and ] straight-line-like patterns of seven line x7 train, as reference marks 35A-35D, and 36A-36D are shown in drawing 8 (d), respectively, these reference marks 35A-35D, and 36A-36D are magnitude settled in the interior of mark image 29AW-30DW of drawing 8 (b). Moreover, reference marks 37A-37D use the lattice point when it corresponds of the grid patterns formed in the direction of X, and the direction of Y in the predetermined pitch, as shown in drawing 8 (e).



[0057] In this case, first, from the result obtained by measurement of steps 103 and 104 in step 105 of drawing 2, the relative physical relationship and the relative angle of rotation of reticle 12 and the RA microscopes 19 and 20 are computed, and the fine alignment marks 29A and 30A of drawing 4 (a) are moved into observation field 19R of the RA microscopes 19 and 20, and 20R, respectively. Then, in step 106, the reference marks 35A and 36A on the reference mark plate 6 of drawing 8 (c) are moved to the observation fields 19R and 20R and the observation fields [ \*\*\*\* ] 19W and 20W (refer to drawing 9), respectively. Thereby, as shown in drawing 9 (a), mark image 29AW and reference mark 35A can observe simultaneously within observation field 19W, and mark image 30AW and reference mark 36A can observe simultaneously within observation field 20W. Then, in step 107 of drawing 2, the detecting signal of the reference mark image which corresponds also with the alignment equipment 34 of an off-axis method is sampled at the same time it changes into an image pick-up signal the image observed under the RA microscopes 19 and 20 and samples it.

[0058] In drawing 9 (a), reticle image 12W which are the projection image of reticle 12 are projected on the reference mark plate 6. Moreover, as shown in drawing 9 (c), the observation fields 19W and 20W are located in the location which crosses the optical axis in the exposure field of a projection optical system 8, respectively, and reference mark 37A is settled in the observation field of the alignment equipment 34 of an off-axis method. And if the reticle minute actuation stage 11 of drawing 7 (b) moves to the bottom (the direction of -y) like the time of slit scan exposure synchronizing with Ztheta shaft actuation stage 4 of drawing 7 (a) moving to an upside (the direction of Y), as shown in drawing 9 (b) from the 9th (a), the reference mark plate 6 and reticle image 12W will move in the direction of Y together. Since the observation fields 19W and 20W of the RA microscopes 19 and 20 and the alignment equipment 34 of an off-axis method are being fixed at this time the mark group (a mark image -- 30 AW 29 AW) by which the bottom of the observation fields 19W and 20W and alignment equipment 34 was given to Sign A Even the mark group (mark image 29DW, 30DW, reference marks 35D, 36D, and 37D) to which Sign D was given from reference marks 35A, 36A, and 37A moves and goes.

[0059] First, in the 1st static position of drawing 9 after alignment initiation (a), mark image 29AW and reference mark 35A are under observation field 19W, there are mark image 30AW and reference mark 36A in the bottom which is observation field 20W, reference mark 37A is under the alignment equipment 34 of an off-axis method, and the mark to which these signs A were given is observed altogether simultaneously. After measurement in the 1st static position is completed, reticle image 12W and the reference mark plate 6 are synchronously moved to the 2nd static position by stepping actuation. The mark groups which the mark group which existed in the 1st static position under the observation fields 19W and 20W and alignment equipment 34 is a mark group to which Sign A was given, and exist in the 2nd static position under the observation fields 19W and 20W and alignment equipment 34 are mark groups (mark image 29BP of drawing 8, reference marks 35B and 37B, etc.) to which Sign B was given.

[0060] By repeating the above sequences with the 3rd static position and the 4th static position (condition of drawing 9 (b)), the reference mark on reticle image 12 the mark image of W and the reference mark plate 6 It will be measured in order of the mark group to which Sign A was given, the mark group to which Sign B was given, the mark group to which Sign C was given, and the mark group to which Sign D was given by the RA microscopes 19 and 20 and the alignment equipment 34 of an off-axis method, respectively. This actuation is actuation of steps 105-110 of drawing 2. Thus, in order to express the measurement result searched for intelligibly, a measurement result is shown in drawing 10.

[0061] In drawing 10, the vector of the alignment error to mark image 29BW-29DW is similarly made into BL-DL from reference marks 35B-35D, respectively by setting to AL the vector of the alignment error from reference mark 35A which amends the measurement result obtained under the RA microscope 19 like the after-mentioned, and is called for to mark image 29AW. Similarly, the vector of the alignment error to mark image 30BW-30DW is made into BR-DR from reference marks 36B-36D, respectively by setting the vector of the alignment error from reference mark 36A to mark image 30AW to AR. Moreover, the error vector from the reference marks 37A-37D which amend the measurement result obtained with the alignment equipment 34 of an off-axis method like the after-mentioned, and are called for to the origin/datum of the alignment equipment 34 is made into AO-DO, respectively.

[0062] And the coordinate value of x directions measured with the interferometer 14 by the side of the reticle of drawing 1 when obtaining the error vector AL, AR-DL, and DR, The coordinate value obtained using the laser beam LRx of drawing 7 (b), respectively Namely, ReAx-ReDx, The coordinate value of the direction of y measured with the interferometer 14 by the side of the reticle of drawing 1 when obtaining the error vector AL, AR-DL, and DR, i.e., the coordinate value obtained using the laser beams LRy1 and LRy2



of drawing 7 (b), is carried out to ReAy1-ReDy1, and ReAy2-ReAy2, respectively. Moreover, the coordinate value of the direction of X measured with the interferometer 13 by the side of the wafer of drawing 1 when obtaining the error vector AL, AR-DL, and DR, The coordinate value obtained using the laser beam LWX of drawing 7 (a), respectively Namely, WaAX-WaDX, The coordinate value of the direction of Y measured with the interferometer 13 by the side of the wafer of drawing 1 when obtaining the error vector AL, AR-DL, and DR, i.e., the coordinate value obtained using the laser beams LWY1 and LWY2 of drawing 7 (a), is carried out to WaAY1-WaDY1, and WaAY2-WaDY2, respectively.

[0063] Moreover, the coordinate value of the direction of X acquired with the interferometer only for alignment equipment of the off-axis method when obtaining error vector AO-DO, i.e., the coordinate value obtained using the laser beam LWOX of drawing 7 (a), is made into WaAOX-WaDOX, respectively. In this case, as shown in drawing 7 (a), spacing of the direction of X of the laser beams LWY1 and LWY2 by the side of a wafer is IL, and spacing by the side of the wafer of the laser beams LRy1 and LRy2 by the side of reticle is RL.

[0064] Next, in order [, such as the error vector AL of drawing 10 ] to explain per [ for which it asks ] way, the configuration of the RA microscope 19 of drawing 1 is explained to a detail. Drawing 11 shows the RA microscope 19 and this illumination system, and the illumination light EL of the same wavelength as exposure light is led to the interior of Ztheta shaft actuation stage 4 through the optical fiber 44 in this drawing 11 from the exterior of Ztheta shaft actuation stage 4. Exposure light may be relayed by the lens system instead of an optical fiber 44. The illumination light drawn such illuminates the reference marks 35A-35D on the reference mark plate 6 through lens 45A, beam-splitter 45B, and lens 45C, and the illumination light which penetrated beam-splitter 45B is illuminating the reference marks 36A-36D on the reference mark plate 6 through lens 45D and lens 45E, Miller 45F, and lens 45G.

[0065] For example, the light which penetrated reference mark 35A carries out image formation of the image of the reference mark 35A on the fine alignment mark 29 on reticle 12 through a projection optical system 8. The light from the image and the alignment mark 29 of the reference mark 35A reaches a half mirror 42 through deflection Miller 15, lens 40A, and lens 40B, and the light carried out 2 \*\*\*\*s by the half mirror 42 carries out incidence to image sensor 43X for the X-axes which consists of two-dimensional CCD, respectively, and the image pick-up side of image sensor 43Y for Y-axes. The image of fine alignment mark 29A as shown in drawing 12 (a), respectively, and reference mark 35 image 35AR is projected on the image pick-up side of these image sensors 43X and 43Y. In this case, image pick-up screen 43Xa of image sensor 43X for the X-axes is a field parallel to the direction of X on a wafer stage, and the direction of a horizontal scanning line is the direction of X, and image pick-up screen 43Ya of image sensor 43Y for Y-axes is a field parallel to the direction of Y on a wafer stage, and the direction of a horizontal scanning line is also the direction of Y.

[0066] Therefore, the amount of location gaps of the direction of X of reference mark 35A and alignment mark 29A is calculated from the averaging of image pick-up signal S4X of image sensor 43X, and the amount of location gaps of the direction of Y of reference mark 35A and alignment mark 29A is calculated from the averaging of image pick-up signal S4Y of image sensor 43Y. These image pick-up signal S4X and S4Y is supplied to the signal processor 41.

[0067] If the mark group to which Sign A was given is explained more to a detail taking the case of the case where alignment is being carried out, under the RA microscope 19, alignment mark 29A and reference mark image 35AR which are shown in drawing 12 (a) will be observed simultaneously. In this drawing 12 (a), picture signal S4X in image pick-up screen 43Xa surrounded with the broken line and 43Ya(s) and S4Y are detected by analog-to-digital conversion as a digital signal within a signal processor 41. Averaging of the image data on each scanning line is independently carried out by the X-axis and the Y-axis within a signal processor 41, and picture signal S4X' for the X-axes and picture signal S4Y' for Y-axes by which averaging was carried out come to be shown in drawing 12 (b) and (c), respectively. These image data is processed as a 1-dimensional image processing signal, respectively.

[0068] thus -- if data processing of the acquired signal is carried out with a signal processor 41 -- relative location gap AL'X of the direction of X with reference mark 35A of the mark image 29AW and the reference mark plate 6 of the reticle 12 of drawing 10 , and the direction of Y And AL'Y It asks. And it is relative location gap AR'X of the direction of X of mark image 30AW and reference mark 36A, and the direction of Y by the RA microscope 20 of drawing 1 . And AR'Y It asks. Similarly, the relative location gap with mark image 29BW-29DW and the reference marks 35B-35D of drawing 10 and the relative location gap with mark image 30BW-30DW and reference marks 36B-36D are called for.

[0069] However, the picture signal corresponding to alignment mark 29A of drawing 12 (b) and the picture

signal corresponding to reference mark image 35AR are having the location controlled, for example by the interferometer by the side of reticle, and the interferometer by the side of a wafer, respectively. Therefore, the measurement coordinate ReAx of the interferometer by the side of the reticle at the time of measuring the mark group (29AW(s) of drawing 10, 35A, 30AW, 36A) to which Sign A was given, and ReAy1 and ReAy2, [ for example, ]  $\Delta WaAX$ , and  $\Delta WaAY1$  and  $\Delta WaAY2$  arise to the measurement coordinate WaAX of the interferometer by the side of a wafer, and WaAY1 and WaAY2. [  $\Delta ReAx$  which is a measurement error (= actual measurement-set point) resulting from the following error of each stage,  $\Delta ReAy1$  and  $\Delta ReAy2$ , and ] Relative location gap AL'X asked for this measurement error for the point by the operation, and AL'Y It is contained.

[0070] then, the result of having deducted those errors from the relative location gap obtained by measurement like a degree type -- the X component ALX and the Y component ALY of Vector AL of drawing 10 It becomes. [ of an alignment error ] however, a degree type -- setting (1/M) -- it is the cutback scale factor of a projection optical system 8, and IL and RL are spacing explained by drawing 7, respectively.

[0071]

[Equation 1]  $ALX = AL'X - \Delta ReAx / M - \Delta WaAX$  [0072]

[Equation 2]  $ALY = AL'Y - \Delta ReAy1 / M - \{(\Delta WaAY1 + \Delta WaAY2) / 2 - (\Delta WaAY2 - \Delta WaAY1) \times RL / IL\}$

[0073] Similarly, it is the X component ARX of the vector AR of the alignment error of drawing 10. And Y component ARY It asks from a degree type.

[0074]

[Equation 3]  $ARX = AR'X - \Delta ReAx / M - \Delta WaAX$  [0075]

[Equation 4]  $ARY = AR'Y - \Delta ReAy2 / M - \{(\Delta WaAY1 + \Delta WaAY2) / 2 - (\Delta WaAY2 - \Delta WaAY1) \times RL / IL\}$

[0076] Next, although error vector AO-DO of drawing 10 which amends the result obtained by the alignment equipment 34 of an off-axis method, and is obtained is explained therefore, with reference to drawing 13, it explains per configuration of the alignment equipment 34.

[0077] Drawing 13 shows the configuration of that alignment equipment 34, and sets it to this drawing 13. The light from the reference mark on the reference mark plate 6 Deviate in the deflection Miller section 46, carry out incidence to the half prism 47, and the light reflected by the half prism 47 tends toward the alignment optical system (henceforth "FIA optical system") 48 of the image-processing method using the white light. The light which penetrated the half mirror carries out incidence to the alignment optical system (henceforth "LIA optical system") 52 for a heterodyne beam to detect the diffracted light from a grid mark.

[0078] First, if it explains from the FIA optical-system 48 side, after the illumination light from the source 49 of the illumination light passes through the FIA optical system 48, it will be deflected by the half prism 47 and deflection Miller 46, and will illuminate the reference mark on the reference mark plate 6. The light which followed the same optical path and passed return and the FIA optical system 48 to the FIA optical system 48 carries out incidence of the return light to half prism 50A. Image formation of the reference mark image on the reference mark plate 6 is carried out on the image pick-up side of image sensor 51X for the X-axes which the flux of light which penetrated half prism 50A becomes from two-dimensional CCD. Image formation of the reference mark image on the reference mark plate 6 is carried out on the image pick-up side of image sensor 51Y for Y-axes which the flux of light reflected by half prism 50A becomes from two-dimensional CCD.

[0079] On the image pick-up side of each image sensor 51X and 51Y, image formation of the image as shown in drawing 14 (a) is carried out. The reference mark on the reference mark plate 6 is the lattice point of a grid-like pattern, and image 37P of the pattern of the shape of the grid are projected on drawing 14 (a). If width of face of P and a dark line is set to L for the grid pitch on the image 37 reference mark plate 6 of P of the pattern of the shape of the grid, width of face L is set up quite smaller than the grid pitch P. Moreover, image formation of the reference mark (index mark) image 48X1 for the directions of X illuminated by the illumination light other than the illumination light of the reference mark plate 6, 48X2 and the index mark image 48Y1 for the directions of Y, and 48Y2 is carried out to the image pick-up side. The location of the reference mark on the reference mark plate 6 is detectable on the basis of the location of these index mark image.

[0080] Specifically, image pick-up field 51Xa of a direction [ \*\*\*\* / as the direction of X / in drawing 14 (a) ] and image pick-up field 51Ya of the direction of Y and a direction [ \*\*\*\* ] are picturized with the image sensors 51X and 51Y of drawing 13, respectively. The directions of the horizontal scanning line of

image sensors 51X and 51Y are the direction of X and the direction of Y, and a direction [ \*\*\*\* ], respectively, and each image pick-up signal S5X of image sensors 51X and 51Y and S5Y are supplied to the signal processor 56 of drawing 13 . In a signal processor 56, averaging of image pick-up signal S5X and the S5Y is carried out, respectively, picture signal S5X' of drawing 14 (b) and picture signal S5Y' of drawing 14 (c) are obtained, and it asks for the location gap of a reference mark made into the object on the reference mark plate 6 from these picture signals. The still more detailed configuration is indicated by Japanese Patent Application No. No. 16589 [ four to ].

[0081] When the reference mark made applicable to detection is reference mark 37A of drawing 10 , a relative location gap of the direction of X over the reference mark of reference mark 37A obtained by the image processing of drawing 14 (a) and the direction of Y is made into AO'fX and AO'fY, respectively. For the location of the reference mark plate 6 at this time, the value which lengthened the following error and rotational error of Ztheta shaft actuation stage 4 of drawing 7 (a) from that measurement result since it was managed by wafer system of coordinates is the X component AOX of the error vector AO of drawing 10 . And Y component AOY It becomes. However, X component AOX corresponding to the FIA optical system 48 of drawing 13 And Y component AOY It is referred to as AOfX and AOfY, respectively. That is, a degree type is obtained.

[0082]

[Equation 5]  $AOfX = AO'fX - (WaAOX - WaAX)$

[0083]

[Equation 6]

$AOfY = AO'fY - (WaAY1 + WaAY2)/2$  [0084] On the other hand, by the alignment system including the LIA optical system 52 of drawing 13 , after the laser beam from a laser light source 53 penetrates the LIA optical system 52 and the half prism 47, it is deflected by deflection Miller 45 and carries out incidence to the reference mark of the shape of a diffraction grating on the reference mark plate 6. Two \*\*\*\*s of the diffracted lights which the diffracted light from the reference mark followed the same optical path, and passed return and the LIA optical system 52 to the LIA optical system 52 are carried out by half prism 50B, and they carry out incidence to photo detector 55Y photo detector 55X for the directions of X, and for the directions of Y.

[0085] In this case, 2 \*\*\*\*s of the laser beams from a laser light source 53 are carried out within the LIA optical system 52, and the delta frequency of deltaf is given to the frequency of these two laser beams by the internal frequency shifter. The interference light of these two laser beams is received by the photo detector 54, and the reference sign S6 of frequency deltaf is outputted from the photo detector. Moreover, by the suitable incident angle with the laser beam (heterodyne beam) from which these two frequencies differ, the reference mark of the shape of a diffraction grating on the reference mark plate 6 irradiates, and the primary [ \*\* ] diffracted light of these [ by the reference mark ] two laser beams returns to parallel vertically to the reference mark plate 6. Although, as for the interference light of the primary [ \*\* ] light, optical reinforcement changes by frequency deltaf, a phase changes according to the X coordinate and Y coordinate of a reference mark. And from photo detector 55X, beat signal S7X of frequency deltaf from which the phase is changing according to the X coordinate of a reference mark is outputted, beat signal S7Y of frequency deltaf from which the phase is changing according to the Y coordinate of a reference mark is outputted from photo detector 55Y, and a reference sign S6 and beat signal S7X, and S7Y are supplied to the signal processor 56.

[0086] If the reference mark for detection is set to reference mark 37A of drawing 10 , the signal processor 56 of drawing 13 is the phase contrast deltaphiX of a reference sign S6 and beat signal S7X, as shown in drawing 14 (d). As location gap AO'LX of the direction of X of reference mark 37A is calculated and it is shown in drawing 14 (e), it is the phase contrast deltaphiY of a reference sign S6 and beat signal S7X. Location gap AO'LX of the direction of Y of reference mark 37A is calculated. The value which lengthened the following error and rotational error of Ztheta shaft actuation stage 4 of drawing 7 (a) from this measurement result is the X component AOX of the error vector AO of drawing 10 . And Y component AOY It becomes. However, X component AOX corresponding to the LIA optical system 52 of drawing 13 And Y component AOY It is referred to as AOLX and AOLY, respectively. That is, a degree type is obtained.

[0087]

[Equation 7]  $AOLX = AO'LX - (WaAOX - WaAX)$

[0088]

[Equation 8]

$AOLY = AO'LY - (WaAY1 + WaAY2)/2$  [0089] If alignment is performed in the location of a mark group where the sign A of drawing 10 was attached as mentioned above, eight data, ALX, ALY, ARX, ARY, AOfX, AOfY, AOLX, and AOLY, will be measured. By performing measurement to the mark group to which the mark group to which Sign A was given by such sequence - Sign D were given, 32 data (= 8x4) are called for. Among these 32 data, the data obtained under the RA microscopes 19 and 20 are memorized as location survey data Dxn and Dyn, and the data obtained by the alignment equipment 34 of an off-axis method are memorized as location survey data Axn and Ayn. Then, actuation shifts to step 111 of drawing 2.

[0090] In step 111 of drawing 2, when the coordinate of the x directions and the direction of y of the system of coordinates which enabled it to change a Reticulum label system and wafer system of coordinates only with a linearity error actually is set to Fxn and Fyn to the location survey data Dxn and Dyn corresponding to the RA microscopes 19 and 20, these relation is as follows.

[0091]

[Equation 9]

$$\begin{bmatrix} F_{xn} \\ F_{yn} \end{bmatrix} = \begin{bmatrix} R_x & -R_x \cdot (\omega + \theta) \\ R_y \cdot \theta & R_y \end{bmatrix} \begin{bmatrix} D_{xn} \\ D_{yn} \end{bmatrix} + \begin{bmatrix} O_x \\ O_y \end{bmatrix}$$

[0092] Moreover, a degree type will be materialized if the nonlinear error of x directions and the direction of y is set to epsilon<sub>xn</sub> and epsilon<sub>yn</sub>.

[0093]

[Equation 10]

$$\begin{bmatrix} \epsilon_{xn} \\ \epsilon_{yn} \end{bmatrix} = \begin{bmatrix} F_{xn} \\ F_{yn} \end{bmatrix} - \begin{bmatrix} D_{xn} \\ D_{yn} \end{bmatrix}$$

$$= \begin{bmatrix} 1 - R_x & -R_x \cdot (\omega + \theta) \\ R_y \cdot \theta & 1 - R_y \end{bmatrix} \begin{bmatrix} D_{xn} \\ D_{yn} \end{bmatrix} + \begin{bmatrix} O_x \\ O_y \end{bmatrix}$$

[0094] And the value of six parameters Rx, Ry, theta, omega, Ox, and Oy of (several 9) is computed using the least squares approximation so that these nonlinear errors (epsilon<sub>xn</sub>, epsilon<sub>yn</sub>) may serve as min. The scaling parameter Rx of x directions shows the scale-factor error of the x directions of reticle 12 and the reference mark plate 6, and the scaling parameter Ry shows the scaling error of the scanning direction (the direction of y) of a Reticulum label system and wafer system of coordinates here. Moreover, in the include-angle parameter theta, reticle 12, the reference mark plate 6, and a rotational error and the include-angle parameter omega show the parallelism of the scanning direction of a Reticulum label system and wafer system of coordinates, and offset parameters Ox and Oy show the offset value of the x directions of both, and the direction of y, respectively.

[0095] Next, the amount of base lines is calculated in steps 112 and 113 of drawing 2. In this case, the offset at the time of the amount measurement of base lines serves as (<Ax>-Ox, <Ay>-Oy) by setting to <Ax> and <Ay> the average value of the data Axn and Ayn measured with the alignment equipment 34 of an off-axis method, respectively. Therefore, at the time of alignment, from the interferometer (it is also hereafter called "the interferometer LWX for exposure") which uses the laser beam LWX of drawing 7 (a), in using a switch and the FIA optical system 48 of drawing 13 for the interferometer (it is also hereafter called "the interferometer LWOFF only for off-axes") using a laser beam LWOFF for control, it sets the average of the measured data Axn and Ayn to <Afx> and <Afy>, respectively. And what is necessary is to give offset of offset (<Afx>-Ox, <Afy>-Oy) to the measurement value of the interferometer corresponding to the laser beams LWY1 and LWY2 of drawing 7 (a), and LWOFF, and just to perform alignment processing. On the other hand, in using the LIA optical system 52 of drawing 13, it sets the average of the measured data Axn and Ayn to <ALx> and <ALy>, respectively. And what is necessary is just to give offset of (<ALx>-Ox, <ALy>-Oy) to the measurement value of an interferometer.

[0096] In addition, the above amendment method means setting up the standard coordinates of stage system of coordinates based on the reference mark on the reference mark plate 6. In this case, in other words, the shaft which passes along the reference marks 37A-37D on the reference mark plate 6, for example turns into a reference axis, and the reading value (yawing value) of the interferometer LWOFF only for off-axes on this reference axis at the time of setting the reading value of the interferometer LWX for exposure to 0 on this reference axis is calculated. And at the time of exposure, alignment of a wafer 5 is carried out for the result of having amended that yawing value to the reading value of the interferometer LWX for exposure, and the

actual reading value of the interferometer LWOFF only for off-axes as "an interferometer value for carrier delivery" based on the interferometer value for these carrier delivery, respectively.

[0097] On the other hand, for example in drawing 7 (a), the approach of setting the reference axis of stage system of coordinates to migration mirror 7X for the X-axes may be used. In this case, the measurement value itself is used, without resetting simultaneously the reading value of the interferometer LWX for exposure, and the reading value of the interferometer LWOFF only for off-axes (0), delivering in the state of drawing 7 (a), first, at the time of future exposure, and using the interferometer value of business. On the other hand, at the time of alignment, tilt-angle thetaXF to migration mirror 7X of the reference axis which passes along the reference marks 37A-37D on the reference mark plate 6 is calculated, and the value which amended IL-theta XF and was acquired is used for the reading value of the interferometer LWOFF only for off-axes using the spacing IL of a laser beam LWX and LWOFF. Thereby, at the time of the usual exposure, the reading value of the interferometer LWX for exposure and the reading value of the interferometer LWOFF only for off-axes can be used now as it is.

[0098] Next, since the measurement data Dxn and Dyn express only the relative error of wafer system of coordinates and a Reticulum label system, when least-squares-approximation count is performed on wafer system-of-coordinates criteria, the called-for parameters Rx, Ry, theta, omega, Ox, and Oy are altogether expressed with the linearity error of the Reticulum label system on the basis of wafer system of coordinates. Then, what is necessary is just to drive reticle based on the Niiza label (rxn, ryn) called for from the degree type according to the motion of wafer system of coordinates, if the x-coordinate and y-coordinate of a Reticulum label system are made into rxn' and ryn', respectively.

[0099]

[Equation 11]

$$\begin{bmatrix} r_{xn} \\ r_{yn} \end{bmatrix} = \begin{bmatrix} R_x & -R_x \cdot (\omega + \theta) \\ R_y \cdot \theta & R_y \end{bmatrix} \begin{bmatrix} r_{xn} \\ r_{yn} \end{bmatrix} + \begin{bmatrix} O_x \\ O_y \end{bmatrix}$$

[0100] Since amendment of Offset Ox and Oy is already made by the reticle side in this processing, it is good only by amending offset of (<Ax>, <Ay>) as an amount of base lines. Moreover, when [ all ] based on a Reticulum label system, it is also possible to bring a result of reverse and to amend by wafer system of coordinates. Moreover, these amendments are amended by wafer system of coordinates at the time of rough alignment, it may divide like carrying out by the Reticulum label system at the time of fine alignment, and it may be controlled.

[0101] Since the check of reticle alignment and the amount of base lines is performed as mentioned above using two or more marks at the time of one reticle alignment according to this example, it becomes possible to equalize the description error of reticle, and reticle and the alignment error of a wafer, and alignment precision improves. Furthermore, since all of these processes are performed to coincidence, a throughput also improves. Furthermore, since the reference mark plate 6 which can measure two or more reference marks simultaneously in a non-scanning direction (the direction of X) is adopted, the error by the air fluctuation of the optical path of an interferometer does not arise.

[0102] However, since the reference mark plate 6 moves to a scanning direction in step, the effect by air fluctuation can be considered. If for the reason the output value of photo detectors 55X and 55Y is used, the location of a wafer stage (Ztheta shaft actuation stage 4 grade) is locked and the check of reticle alignment and the amount of base lines is performed at the time of the check of the amount of base lines in case processing which used the LIA optical system 52 of drawing 13 is performed, the effect of air fluctuation will be suppressed to the minimum. Moreover, the reticle mark of this example is arranged at a total of eight places of four corners of reticle 12. In order to investigate the response relation between a Reticulum label system and wafer system of coordinates, not only offset but the parameters Rx, Ry, theta, and omega are required for this, and it is because it is more advantageous to the decision of Parameters Ry, theta, and omega to have arranged the mark in four corners. Furthermore, when using the luminescent reference mark plate 6, it is because it is difficult for a light-emitting part to have a limit and to make the whole surface on the reference mark plate 6 emit light.

[0103] Moreover, when the number of reticle marks on reticle 12 is set to n, offset parameters Ox and Oy are 1/n<sup>1/2</sup>. It is equalized and the error of other parameters also becomes small. Therefore, an error becomes small, so that reticle mark several n is increased. The result of having carried out simulation of the relation between the error of reticle mark several n and a parameter and the error of the amount of base lines to below is shown. Below, it is 3 times the standard deviation sigma, and a unit [nm] expresses dispersion in four corners in the Niiza label system of (several 11).

[0104]

[A table 1]

レチクル マーク数 n	RX, Ry, $\theta$ , $\omega$ の誤差		ベースライン量 の誤差		
座標軸	X	Y	X	Y	悪い方の自乗和
4	9.59	10.96	8.8	7.2	16.00
8	7.10	7.92	6.2	5.1	9.43
12	5.86	6.48	5.1	4.2	7.77
16	5.03	5.80	4.4	3.6	6.83

[0105] As mentioned above, by making reticle mark several n into eight pieces shows that precision of the check of 50nm and the stepping error of a stage of reticle alignment and the amount of base lines also as 10nm is made to 10nm or less by the reticle drawing error. That is, if it is less than a limit of the luminescent reference mark plate 6, processing speed is carried out early and many reticle mark several n is taken, it will also become possible to raise precision more.

[0106] In this case, although the patterning error on the reference mark plate 6 and the distortion error of a projection optical system 8 remain as errors into the Niiza label system, since these do not almost have fluctuation, it will be satisfactory if the error acquired in the exposure result as compared with reference data at the time of equipment adjustment is removed as system offset. In addition, in the above-mentioned example, as shown in drawing 8 (c), on the reference mark plate 6, two or more reference marks 35A-35D are formed, and two or more reference marks 37A-37D are also formed. However, even if it uses only one reference mark 35A and one reference mark 37A, for example, the effect of the drawing error of the pattern on reticle 12 can be reduced by scanning only reticle 12 and equalizing a measurement result.

[0107] Next, it explains with reference to the flow chart of drawing 15 per 2nd example of this invention, and drawing 16. It was what the reticle alignment mode of the 1st above-mentioned example uses 4 sets of fine alignment marks 29A-29D on reticle, and 30A-30D about this, and performs reticle alignment of FAIN. However, when the parallelism of the Reticulum label system of the scaling error of the scanning direction or the scanning direction and wafer system of coordinates is small after reticle alignment of FAIN is once performed by the approach of the 1st example, it may be made to perform reticle alignment and base-line measurement using 1 set of fine alignment marks. Thus, the alignment mode in which measurement to three items of scale-factor (Rx) measurement of the non-scanning direction, rotation (theta) measurement, and base-line measurement is carried out using 1 set of fine alignment marks is called "quick mode." This quick mode can be applied also when it turns out beforehand that the drawing error of the fine alignment marks 29A-30D on reticle 12 is still smaller.

[0108] In this quick mode, measurement to three items of scale-factor (Rx) measurement of the non-scanning direction, rotation (theta) measurement, and base-line measurement is carried out, for example using 1 set of fine alignment marks 29A and 30A on reticle 12, 1 set of reference marks 35A and 36A on the reference mark plate 6, and one reference mark 37A on the reference mark plate 6. However, in order to amend the drawing error of 1 set of fine alignment marks 29A and 30A in the case of this quick mode, it is necessary to memorize the drawing error of Marks 29A and 30A searched for by the fine alignment sequence.

[0109] Actuation of this 2nd example is explained with reference to drawing 15 and drawing 16. Actuation of drawing 15 and drawing 16 is the actuation which added quick mode to actuation of drawing 2, and fine mode and quick mode can switch it. In the step of drawing 15, the same sign is given to the step corresponding to the step of drawing 2, and the detail explanation is omitted.

[0110] In drawing 15, like [ steps / 101-104 ] the case of drawing 2, reticle 12 is laid on a reticle electrode holder, and the RA microscopes 19 and 20 detect the location of the alignment marks 27 and 28 for a rough search, respectively. Next, one of fine mode and the quick modes is chosen at step 115. This selection result is beforehand directed by the operator through keyboard 22C of drawing 1. However, the pattern information on reticle 12 etc. is read by the non-illustrated bar code reader, and you may make it main control system 22A choose alignment mode automatically based on this result.



[0111] If fine mode is chosen, steps 105-113 of drawing 15 will be performed, and base-line measurement using the measurement result of the reticle alignment using two or more fine alignment marks and two or more reference marks and fine alignment will be performed like the above-mentioned. And at step 114, in the Niiza label system top on reticle 12, the drawing error (henceforth a "mark error") of the location of the actual fine alignment marks 29A and 30A to an original location is searched for, and the mark error is memorized in the storage section in main control system 22A. In case a mark error is searched for, from the relation (conversion parameter) for which it asked at step 113, it asks for a Reticulum label system on the basis of wafer system of coordinates, and the nonlinear error of the measured coordinate value to the coordinate value on the fine alignment marks 29A-29D and the design of 30A-30D is searched for on this Reticulum label system. This nonlinear error turns into a mark error. Thus, the mark error on the Niiza label system on reticle is memorized from the result of steps 112 and 113 at the time of fine alignment. Moreover, when the reticle drawing error is measured beforehand, an operator may do the direct input of the drawing error. Effectiveness is large especially when a linearity component is contained in a drawing error.

[0112] On the other hand, if quick mode is chosen at step 115, actuation will shift to step 116 of drawing 16. And in steps 116-118, the same actuation as steps 105-107 of drawing 15 is performed. That is, the image of one pair of fine alignment marks 30A and 29A on reticle 12 and one pair of reference marks 36A and 35A on the reference mark plate 6 is observed under RA microscope in quick mode, and the alignment equipment 34 of an off-axis method detects one reference mark 37A. Moreover, it asks for the location of the mark detected with the alignment equipment 34 of the mark observed under RA microscope in the second half and off-axis method of step 119. Then, in step 119, the mark error searched for at step 114 of drawing 15 is amended to the location where the fine alignment marks 30A and 29A on reticle 12 were detected. Thereby, the number of the mark measured in quick mode can amend the pattern drawing error on reticle 12 at least almost to the same extent as the case in the fine alignment mode of the 1st example.

[0113] Next, in step 120, the scale-factor error Rx of the non-scanning direction of the six conversion parameters (Rx, Ry, theta, omega, Ox, Oy) of (several 9), Rotation theta, and Offset Ox and Oy are searched for based on the location of each mark obtained by amendment at step 119. As shown in drawing 8 (a) and (c), specifically, the scale-factor error Rx of the non-scanning direction is searched for from the difference of mark spacing of the direction of X of the surveyed reference marks 35A and 36A (the non-scanning direction), and spacing of the direction of X of mark image 29AW and 30AW. Furthermore, it asks for Rotation theta from the difference and mark spacing of a location gap of the direction (the scanning direction) of Y of reference marks 35A and 36A, and a location gap of the direction of Y of mark image 29AW and 30AW. Moreover, Offset Ox and Oy is calculated from the average amount of location gaps of a reference mark and the mark image of reticle.

[0114] In addition, in this quick mode, since the mark made applicable to measurement is two pieces at a time in the reticle and reference mark plate 6 side, it can determine conversion 4 of six conversion parameters of (several 9). Then, the value of four conversion parameters is calculated as mentioned above. In addition, the scale-factor error Ry of a scanning direction can be searched for by choosing for measurement two fine alignment marks 29A and 29D located in a line, for example in the direction of Y of drawing 4, and two reference marks 35A and 35D of drawing 8 (c).

[0115] And reticle alignment is performed based on the scale-factor error Rx of the non-scanning direction and Rotation theta which were called for at step 120, and Offset Ox and Oy. In addition, measurement of a scale-factor error prepares beforehand the scale-factor error corresponding to a part for the gap of the measurement value of each mark to the design value of each mark as a table, and it applies a part for the gap of the measurement value of each mark to the design value of each mark to the table, and you may make it search for a scale-factor error.

[0116] Next, in step 121, base-line measurement is performed using the measurement value of the main coordinate of reference marks 35A and 36A, and the measurement value of reference mark 37A. Thus, since it is amending the mark error in according to this example performing fine alignment mode once, searching for the drawing error (mark error) of the pattern of reticle 12 and performing alignment in quick mode, it is a high throughput and alignment of the projection aligner of a slit scan method can be carried out to high degree of accuracy.

[0117] Next, with reference to the flow chart of drawing 17, it explains per 3rd example of this invention. Whenever it carries out predetermined number-of-sheets exchange of the wafer (i.e., whenever this 3rd example is exposed to the wafer of predetermined number of sheets), it performs reticle alignment and base-line measurement in above-mentioned quick mode. In this example, after exchanging reticles with the projection aligner of drawing 1, an example of actuation in the case of carrying out sequential exposure of

the pattern of reticle 12 is explained to several 100 wafers with reference to drawing 17.

[0118] First, in step 211 of drawing 17, the reticle used before is exchanged for the reticle 12 of drawing 1, and exposure actuation is started. In this case, reticle alignment in the quick mode which drawing 15 reaches step 101-104 and is shown in steps 116-121 of drawing 16 at 115 and a list, and actuation of a base-line check are performed. Then, the number of sheets of the wafer which will be exposed by the time it performs reticle alignment and a base-line check next as initial value at step 212 is set as Variable N, and a wafer is loaded to it on the wafer stage 4 at step 213. However, a new wafer is loaded after performing the unload (taking out) of a wafer [ finishing / the exposure ], when there is a wafer already exposed at step 213.

[0119] Next, it is investigated whether it is the timing which performs whether Variable N is 0 and reticle alignment, i.e., a base-line check, at step 214, and when Variable N is larger than 0, 1 is subtracted from Variable N at step 215, and it shifts to step 216. At this step 216, after performing alignment of a wafer using the wafer alignment system of the alignment equipment 34 of the off-axis method of drawing 13, or a TTL method, the pattern of reticle 12 is exposed by each shot field of a wafer. When no exposure to wafers has finished although the exposure process about the reticle 12 is ended after the exposure to a wafer [ all (assignment number of sheets) ] is completed, it returns to step 213 and the unload of a wafer [ finishing / exposure ] and loading of a new wafer are performed. Actuation shifts to step 214 after that.

[0120] Moreover, when it is the timing which performs  $N=0$ , i.e., reticle alignment, and a base-line check at step 214, in step 217, measurement of the rotational error of reticle 12 and a scale-factor error is performed. This is the same as that of step 120 of drawing 16. Then, it shifts to step 218 and the base-line check of the direction of X of the alignment equipment 34 (wafer alignment system of 2 flux-of-light interference alignment method including an alignment system or the LIA optical system 52 including the FIA optical system 48) of an off-axis method and the direction of Y is performed here. Then, after setting up the number of sheets of the wafer which will be exposed by the time it performs a base-line check next as a variable N at step 219, actuation returns to step 216.

[0121] Thus, since reticle alignment and base-line measurement are performed in quick mode whenever it exposes to the wafer of predetermined number of sheets while performing reticle alignment and base-line measurement according to this example, whenever it exchanges reticles, the superposition precision of each wafer and the pattern image of reticle can be raised by the high throughput.

[0122] Moreover, although the technique of the above-mentioned example is explained about the base-line measurement at the time of the alignment of an off-axis method, it can expect the same effectiveness by application of this invention also in the TTL (through THE lens) method using the inside of the field of a projection optical system. Thus, this invention is not limited to the above-mentioned example, but can take configurations various in the range which does not deviate from the summary of this invention.

[0123]

[Effect of the Invention] According to the 1st projection exposure approach of this invention, the effect of the drawing error of the mark for measurement on a mask can be small suppressed by asking for the parameter (offset of a scale factor, the scaling of a scanning direction, a revolution, the parallelism of a scanning direction, the direction of X, and the direction of Y) which matches mask system of coordinates and substrate system of coordinates by the least squares approximation etc. according to the location gap called for eventually in each location of two or more marks for measurement on a mask.

[0124] Moreover, according to the 2nd projection aligner, by equalizing the measurement result about two or more marks for measurement by the side of a mask, the drawing error of the mark for measurement of a mask is made small, and the amount of base lines which is spacing of the origin/datum of a projection optical system and the origin/datum of an alignment system can be measured to accuracy. Moreover, while according to the 3rd projection aligner making it correspond to two or more marks for measurement on a mask and forming two or more the 1st reference mark on a reference mark member Since two or more the 2nd reference mark is formed from the 1st reference mark of these plurality at spacing corresponding to spacing of the reference point in the exposure field of a projection optical system, and the reference point of the alignment system of an off-axis method, respectively, Since equalization is performed also for a reference mark side, the amount of base lines is measured more by accuracy.

[0125] Moreover, according to the 4th projection exposure approach of this invention, it can ask for the response relation between the system of coordinates on a mask, and the system of coordinates on a stage by the high throughput by choosing the simple measurement process by quick mode if needed. Moreover, according to the 5th projection exposure approach, the response relation and the amount of base lines of the system of coordinates on a mask and the system of coordinates on a stage can be calculated by the high throughput by choosing the simple measurement process by quick mode if needed.

[0126] Moreover, according to the 6th projection exposure approach, when exposing by the scanning method continuously to many substrates since the simple measurement process by quick mode is performed whenever it exposes to the substrate of predetermined number of sheets, the response relation and the amount of base lines of the system of coordinates on a mask and the system of coordinates on a stage can be calculated by the high throughput.

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[Translation done.]

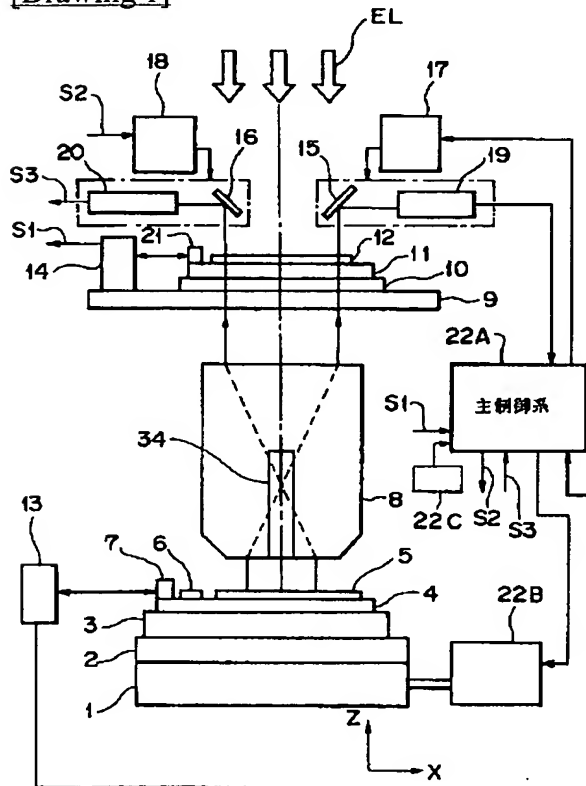
## \* NOTICES \*

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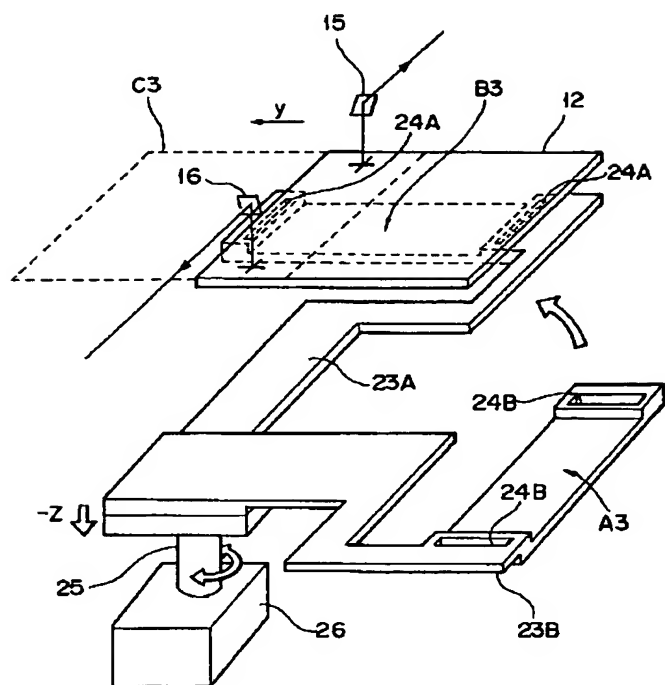
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

## DRAWINGS

[Drawing 1]



[Drawing 3]

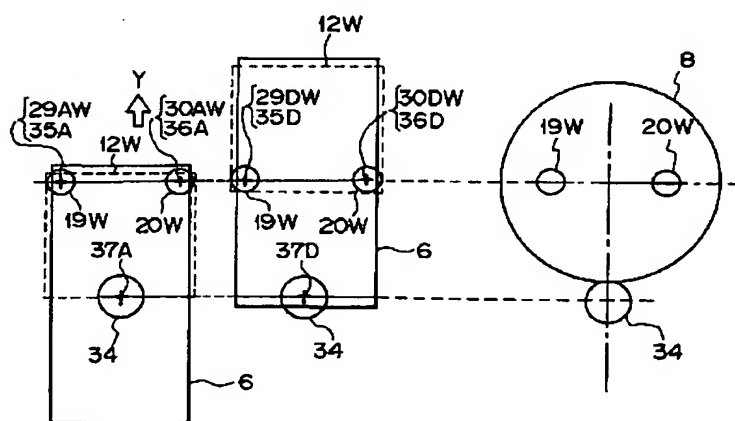


[Drawing 9]  
(a)

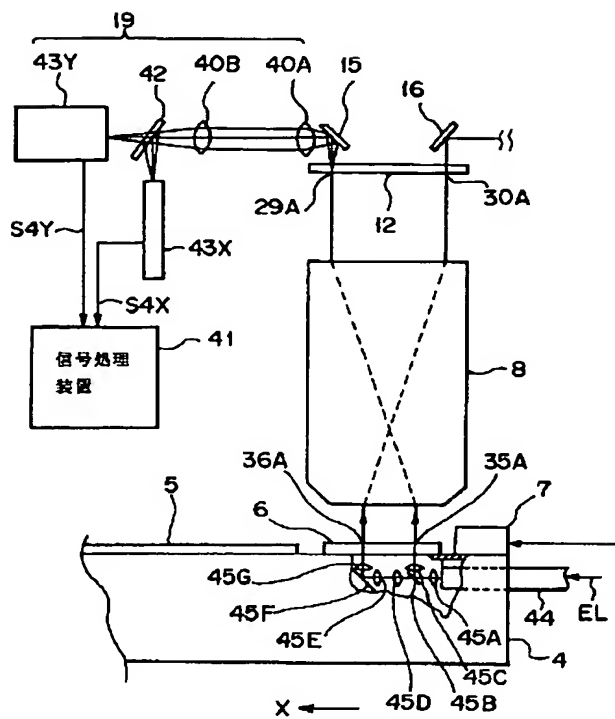
(a)

(b)

(c)

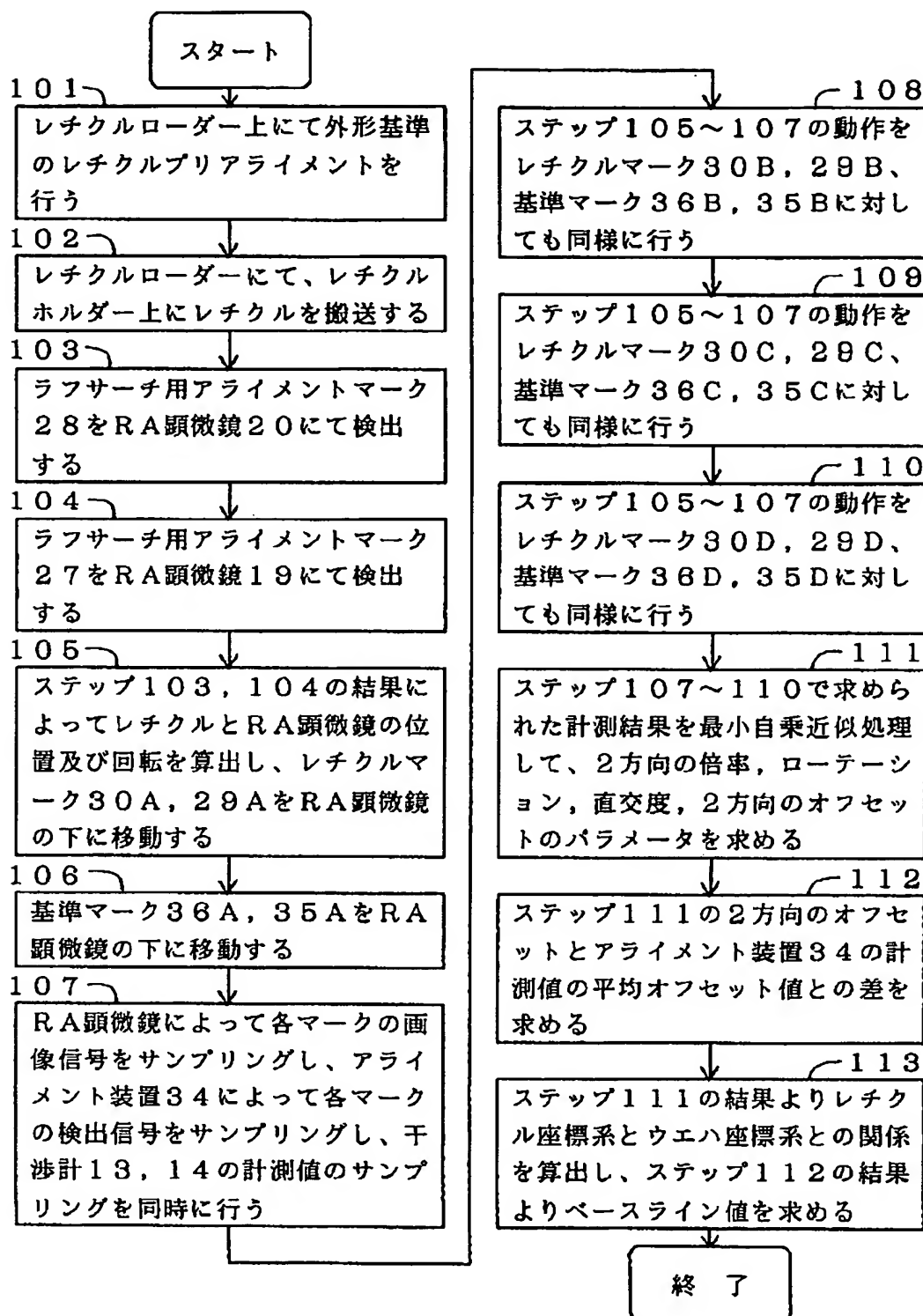


[Drawing 11]

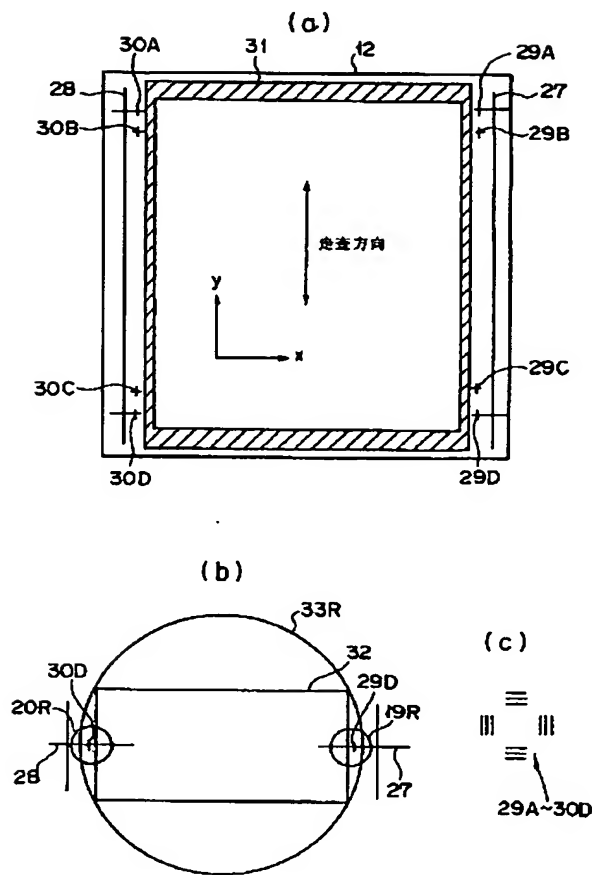


[Drawing 2]

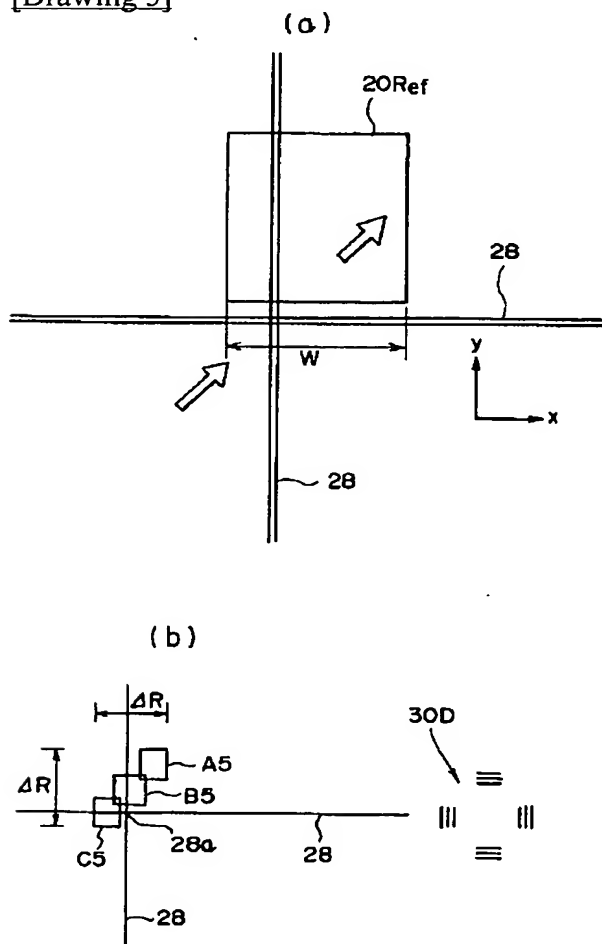




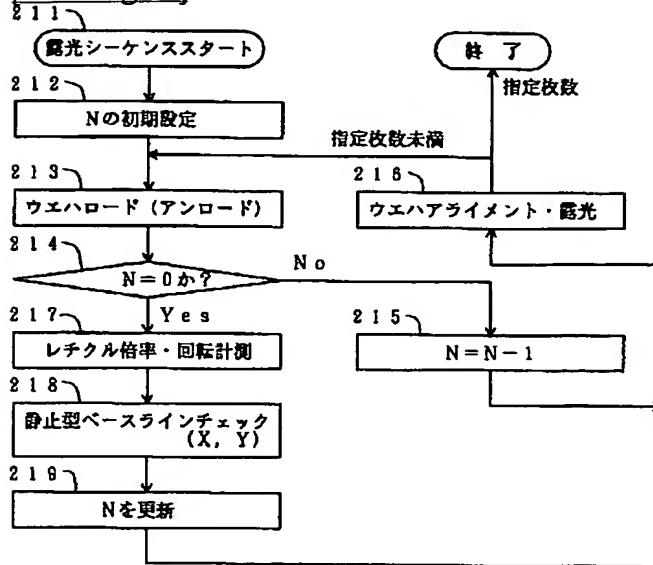
[Drawing 4]



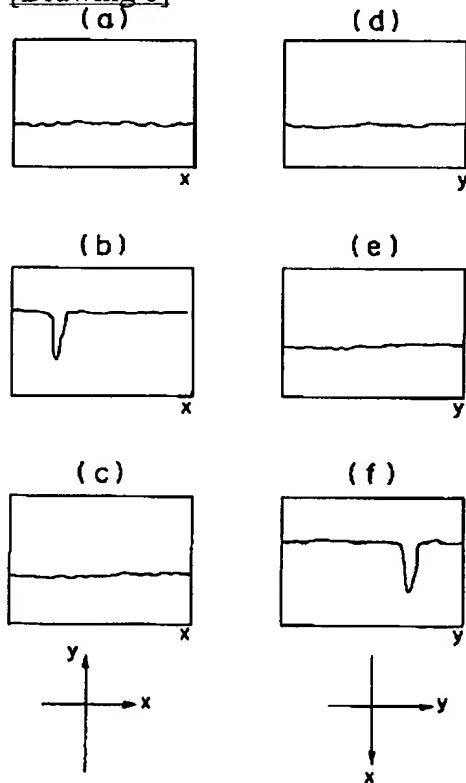
[Drawing 5]



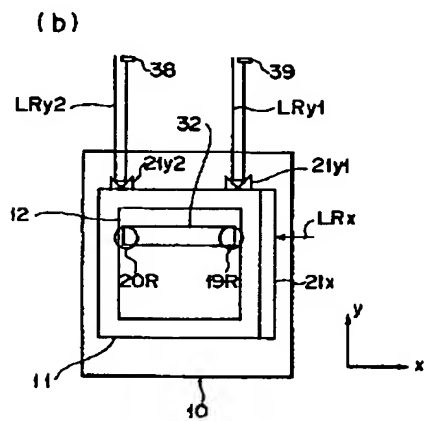
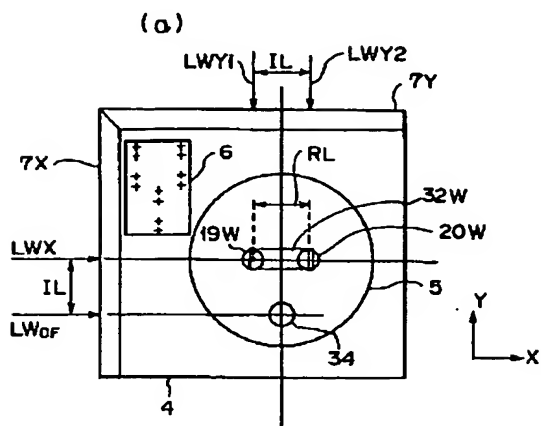
[Drawing 17]



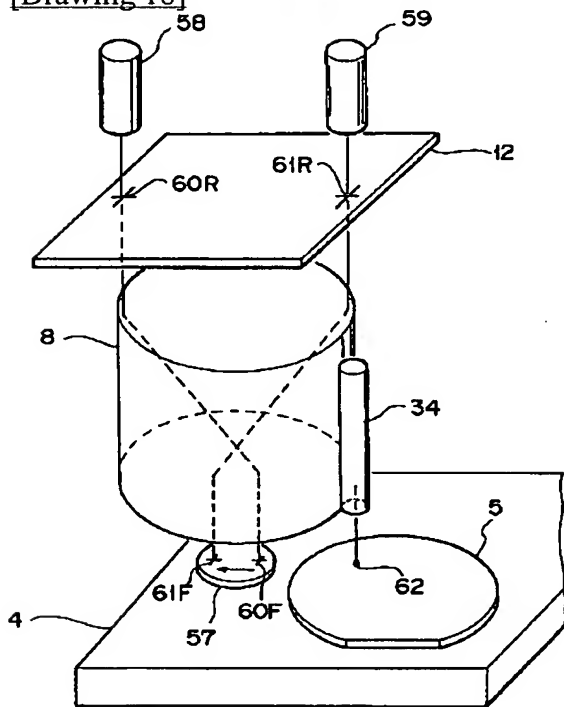
[Drawing 6]



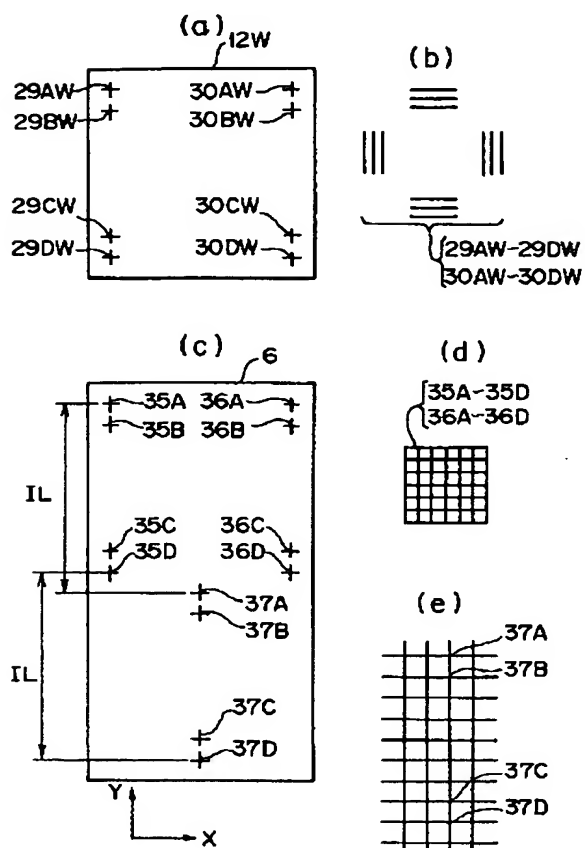
[Drawing 7]



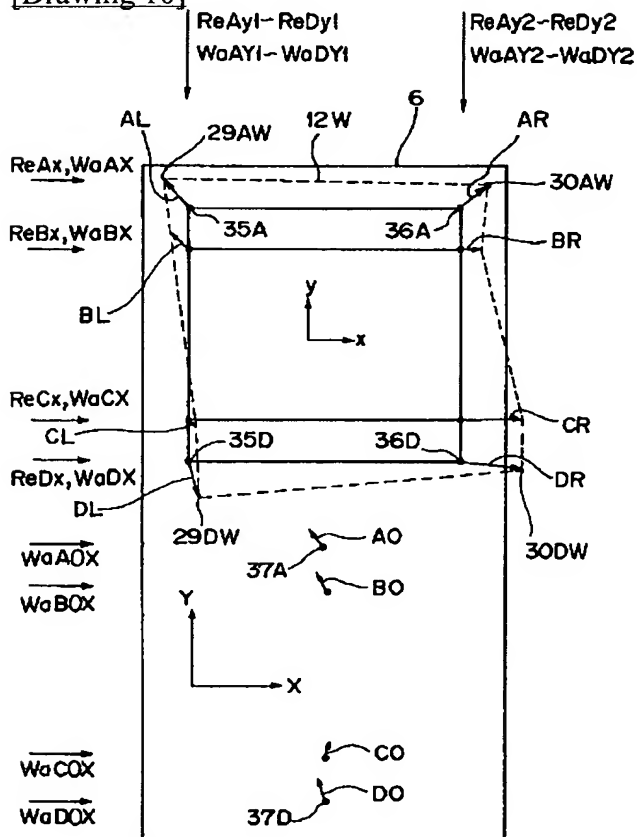
[Drawing 18]



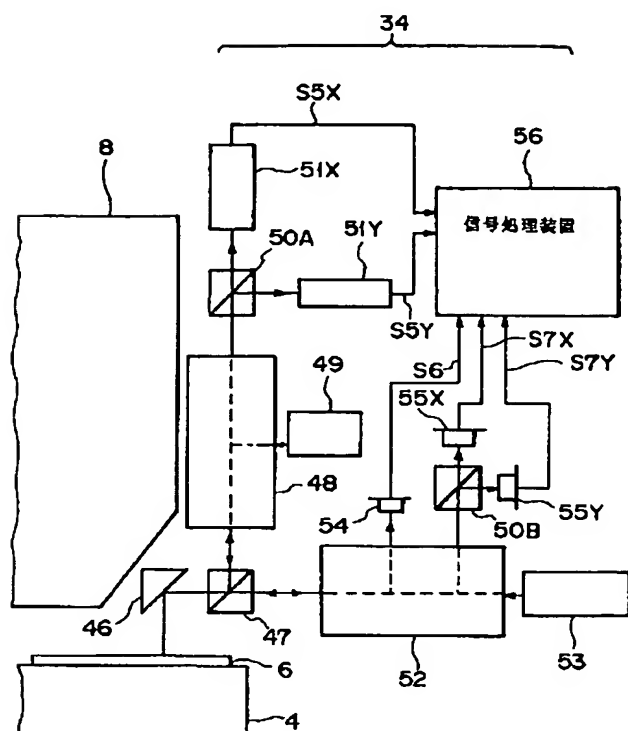
[Drawing 8]



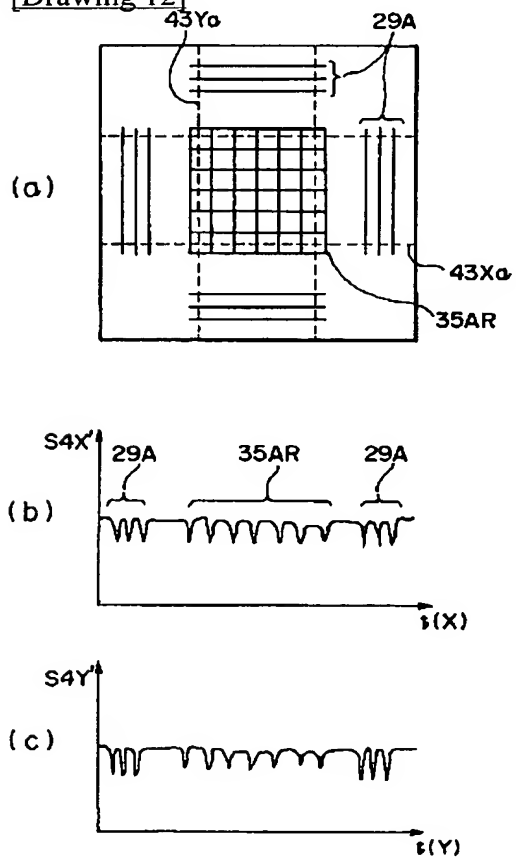
[Drawing 10]



[Drawing 13]

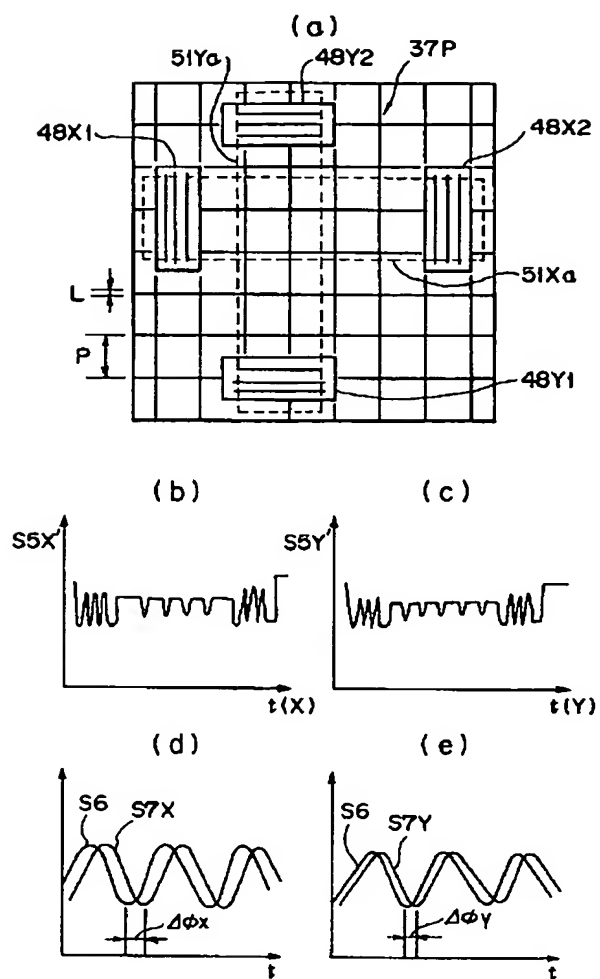


[Drawing 12]

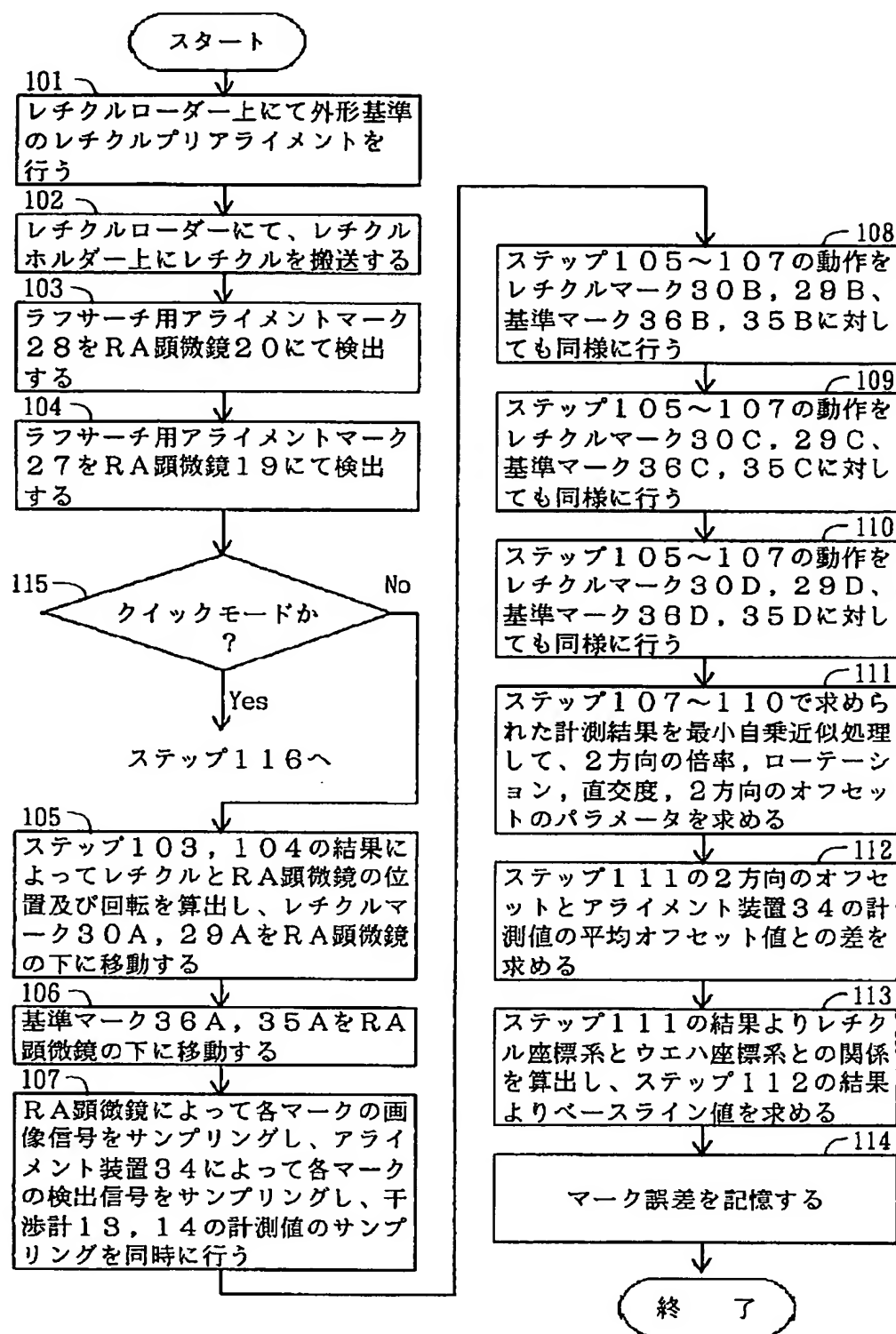


[Drawing 14]

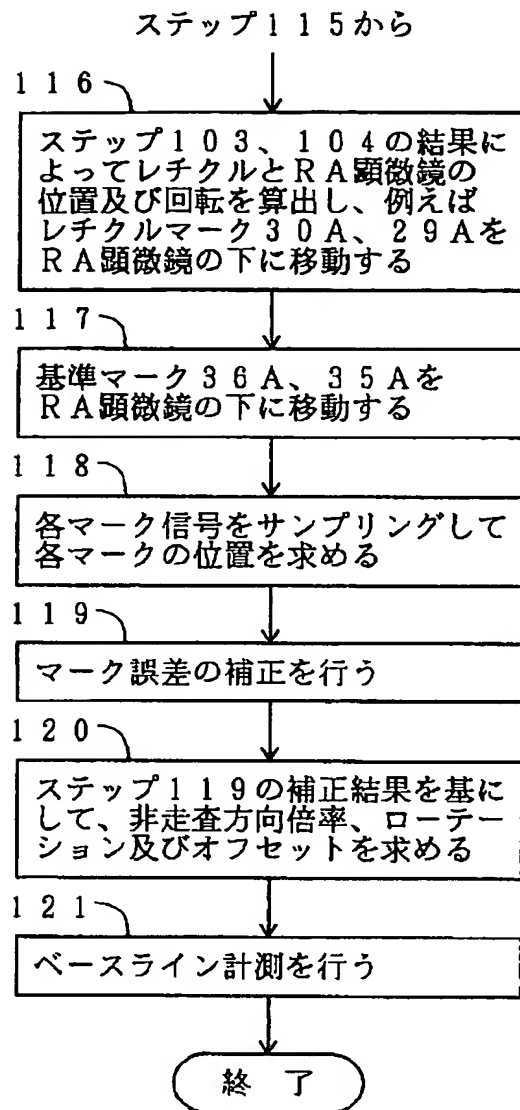




[Drawing 15]



[Drawing 16]



[Translation done.]

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**CORRECTION OR AMENDMENT**


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[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law  
 [Category partition] The 2nd partition of the 7th category  
 [Publication date] August 3, Heisei 13 (2001. 8.3)

[Publication No.] JP,7-176468,A  
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 [Annual volume number] Open patent official report 7-1765  
 [Application number] Japanese Patent Application No. 5-334759  
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 G03B 27/32  
 G03F 7/20 521  
 9/00

[FI]

H01L 21/30 525 C  
 G03B 27/32 F  
 G03F 7/20 521  
 9/00 H  
 H01L 21/30 520 A

[Procedure amendment]  
 [Filing Date] September 13, Heisei 12 (2000. 9.13)  
 [Procedure amendment 1]  
 [Document to be Amended] Description  
 [Item(s) to be Amended] The name of invention  
 [Method of Amendment] Modification  
 [Proposed Amendment]  
 [Title of the Invention] It is an aligner to the projection exposure approach and equipment, and a list.  
 [Procedure amendment 2]  
 [Document to be Amended] Description  
 [Item(s) to be Amended] Claim  
 [Method of Amendment] Modification  
 [Proposed Amendment]  
 [Claim(s)]

[Claim 1] Illuminate the lighting field of a predetermined configuration by the illumination light, and the pattern image on the mask in the lighting field of said predetermined configuration is exposed to the substrate on a stage through a projection optical system. In the projection exposure approach which exposes the pattern image of an area larger than the lighting field of said predetermined configuration on said mask on said substrate by scanning said mask and said substrate synchronously relatively to the lighting field of said predetermined configuration,

The reference mark member which forms two or more marks for measurement towards said relative scan and by which two or more reference marks were formed in these two or more marks for measurement and a location [ \*\*\*\* / almost ] on said mask is arranged on said stage,

Said mask and said substrate are moved synchronizing with the direction of said relative scan, and sequential measurement of the amount of location gaps of one mark for measurement in two or more marks for measurement on said mask and the reference mark to which it corresponds on said stage is carried out, The projection exposure approach characterized by asking for the response relation between the system of coordinates on said mask, and the system of coordinates on said stage from each amount of location gaps of said two or more marks for measurement and said two or more reference marks.

[Claim 2] Illuminate the lighting field of a predetermined configuration by the illumination light, and the pattern image on the mask in the lighting field of said predetermined configuration is exposed to the substrate on a stage through a projection optical system. In the projection exposure approach which exposes the pattern image of an area larger than the lighting field of said predetermined configuration on said mask on said substrate by scanning said mask and said substrate synchronously relatively to the lighting field of said predetermined configuration,

The alignment system of the off-axis method for detecting the location of the mark for positioning on said substrate near said projection optical system is arranged. Two or more marks for measurement are formed towards said relative scan on said mask. The reference mark member in which the 1st and 2nd reference marks were formed at spacing corresponding to spacing of the reference point in the exposure field of said projection optical system and the reference point of the alignment system of said off-axis method is arranged on said stage,

Where said 2nd reference mark on said criteria member is observed by the alignment system of said off-axis method, said mask is moved towards said relative scan, and sequential measurement of the amount of location gaps of one mark for measurement in two or more marks for measurement on said mask and said 1st reference mark on said stage is carried out,

The projection exposure approach characterized by asking for spacing of the reference point in the exposure field of said projection optical system, and the reference point of the alignment system of said off-axis method from the amount of location gaps of said 2nd reference mark observed by the average of each amount of location gaps of said two or more marks for measurement and said 1st reference mark, and the alignment system of said off-axis method.

[Claim 3] While making it correspond to two or more marks for measurement on said mask and forming two or more said 1st reference mark on said reference mark member, two or more said 2nd reference mark is formed from these two or more 1st reference marks at spacing corresponding to spacing of the reference point in the exposure field of said projection optical system, and the reference point of the alignment system of said off-axis method, respectively,

Said mask and said stage are moved synchronizing with the direction of said relative scan, and while carrying out sequential measurement of the amount of location gaps of one mark for measurement in two or more marks for measurement on said mask, and said 1st reference mark to which it corresponds on said stage, the reference mark to which it corresponds of said two or more 2nd reference marks by the alignment system of said off-axis method is observed,

The approach according to claim 2 characterized by asking for spacing of the reference point in the exposure field of said projection optical system, and the reference point of the alignment system of said off-axis method from the average of the amount of location gaps of two or more of said 2nd reference marks observed by the average of each amount of location gaps of said two or more marks for measurement and said two or more 1st reference marks, and the alignment system of said off-axis method.

[Claim 4] Illuminate the lighting field of a predetermined configuration by the illumination light, and the pattern image on the mask in the lighting field of said predetermined configuration is exposed to the substrate on a stage through a projection optical system. In the projection exposure approach which exposes the pattern image of an area larger than the lighting field of said predetermined configuration on said mask on said substrate by scanning said mask and said substrate synchronously relatively to the lighting field of said predetermined configuration,

The reference mark member which forms two or more marks for measurement towards said relative scan and by which two or more reference marks were formed in these two or more marks for measurement and a location [ \*\*\*\* / almost ] on said mask is arranged on said stage,

Said mask and said substrate are moved synchronizing with the direction of said relative scan. Sequential measurement of the amount of location gaps of one mark for measurement in two or more marks for measurement on said mask and the reference mark to which it corresponds on said stage is carried out. The 1st process which calculates each amount of location gaps of said mark for measurement and said reference mark; The amount of location gaps of one mark for measurement predetermined [ of two or more marks for

measurement on said mask ] and the reference mark to which it corresponds on said stage is measured only once. The 2nd process which calculates the amount of location gaps of said mark for measurement and said reference mark; One of said 1st process and said 2nd process is chosen. The projection exposure approach characterized by having the 3rd process which asks for the response relation between the system of coordinates on said mask, and the system of coordinates on said stage based on each amount of location gaps of the mark for [ with which it asked at the selected process ] said measurement, and said reference mark, and;

[Claim 5] Illuminate the lighting field of a predetermined configuration by the illumination light, and the pattern image on the mask in the lighting field of said predetermined configuration is exposed to the substrate on a stage through a projection optical system. In the projection exposure approach which exposes the pattern image of an area larger than the lighting field of said predetermined configuration on said mask on said substrate by scanning said mask and said substrate synchronously relatively to the lighting field of said predetermined configuration,

The alignment system of the off-axis method for detecting the location of the mark for positioning on said substrate near said projection optical system is arranged,

The reference mark member which forms two or more marks for measurement towards said relative scan and by which two or more reference marks were formed in these two or more marks for measurement and a location [ \*\*\*\* / almost ] on said mask is arranged on said stage, and these two or more reference marks consist of the 1st and 2nd reference marks arranged at spacing corresponding to spacing of the reference point of said projection optical system, and the reference point of the alignment system of said off-axis method,

The projection exposure approach characterized by providing the following Where said 2nd reference mark on said reference mark member is observed by the alignment system of said off-axis method Said mask is moved towards said relative scan. The 1st process which carries out sequential measurement of the amount of location gaps of one mark for measurement in two or more marks for measurement on said mask, and said 1st reference mark; where said 2nd reference mark on said reference mark member is observed by the alignment system of said off-axis method The 2nd process which measures the amount of location gaps of one predetermined mark for measurement in two or more marks for measurement on said mask, and said 1st reference mark; It is as a result of [ in the 3rd process which chooses one of said 1st process and said 2nd process, and the process chosen at the; this 3rd process ] measurement. It is the response relation between the system of coordinates on said mask, and the system of coordinates on said stage from each amount of location gaps of said mark for measurement and said reference mark, and the amount of location gaps of said 2nd reference mark observed by the alignment system of said off-axis method. The 4th process which asks for spacing of the reference point in the exposure field of said projection optical system, and the reference point of the alignment system of said off-axis method;

[Claim 6] Illuminate the lighting field of a predetermined configuration by the illumination light, and the pattern image on the mask in the lighting field of said predetermined configuration is exposed to the substrate on a stage through a projection optical system. In the projection exposure approach which exposes the pattern image of an area larger than the lighting field of said predetermined configuration on said mask on said substrate by scanning said mask and said substrate synchronously relatively to the lighting field of said predetermined configuration,

The alignment system of the off-axis method for detecting the location of the mark for positioning on said substrate near said projection optical system is arranged,

The reference mark member which forms two or more marks for measurement towards said relative scan and by which two or more reference marks were formed in these two or more marks for measurement and a location [ \*\*\*\* / almost ] on said mask is arranged on said stage, and these two or more reference marks consist of the 1st and 2nd reference marks formed at spacing corresponding to spacing of the reference point of said projection optical system, and the reference point of the alignment system of said off-axis method, Whenever it carries out predetermined number-of-sheets exchange of said substrate,

Where said 2nd reference mark on said reference mark member is observed by the alignment system of said off-axis method The amount of location gaps of one predetermined mark for measurement in two or more marks for measurement on said mask and said 1st corresponding reference mark is measured. From the measured this amount of location gaps, and the amount of location gaps of said 2nd reference mark observed by the alignment system of said off-axis method, the response relation between the system of coordinates on said mask, and the system of coordinates on said stage, The projection exposure approach characterized by asking for spacing of the reference point in the exposure field of said projection optical system, and the

reference point of the alignment system of said off-axis method.

[Claim 7] In the projection exposure approach which carries out scan exposure of said substrate using the pattern of said mask by moving synchronously each of the mask with which the pattern was formed, and the substrate as an object for exposure,

In advance of said scan exposure, the 1st stage and this 1st stage holding said mask are the projection exposure approach characterized by searching for the information for carrying out scan exposure of said substrate by holding said substrate independently, moving at least one side with the 2nd movable stage to a predetermined scanning direction, and moving relatively on said 1st stage and said 2nd stage.

[Claim 8] The scanning direction of said 1st stage is prescribed by the 1st interferometer systems which measure the positional information of said 1st stage,

The scanning direction of said 2nd stage is an approach according to claim 7 characterized by what is prescribed by the 2nd interferometer systems which measure the positional information of said 2nd stage.

[Claim 9] The approach according to claim 7 or 8 characterized by moving each of said 1st stage and said 2nd stage to a mutually different scanning direction in said relative migration.

[Claim 10] Said relative migration is an approach according to claim 9 characterized by being carried out like the time of scan exposure of said substrate.

[Claim 11] Said relative target is an approach according to claim 10 characterized by moving said 1st stage and said 2nd stage synchronously in migration.

[Claim 12] Said relative migration is an approach according to claim 7 or 8 characterized by including migration of only said 1st stage.

[Claim 13] An approach given in any 1 term of claims 7-12 characterized by detecting the mark on said 1st stage and searching for the information for carrying out scan exposure of said substrate while moving relatively on said 1st stage and said 2nd stage.

[Claim 14] The approach according to claim 13 characterized by arranging two or more marks left to said scanning direction on said 1st stage.

[Claim 15] The mark on said 1st stage is an approach according to claim 13 or 14 characterized by being detected with the mark on said 2nd stage.

[Claim 16] The approach according to claim 15 characterized by arranging two or more marks left to said scanning direction on said 2nd stage.

[Claim 17] The information for carrying out scan exposure of said substrate is an approach given in any 1 term of claims 7-16 characterized by including the information for carrying out the synchronized drive of said mask and said substrate by position relation.

[Claim 18] The information for carrying out scan exposure of said substrate is an approach given in any 1 term of claims 7-17 characterized by being the information about response relation with the 2nd system of coordinates for controlling the 1st system of coordinates for controlling migration of said 1st stage, and migration of said 2nd stage.

[Claim 19] In the projection exposure approach which carries out scan exposure of the substrate using the pattern of said mask by moving synchronously the mask with which the pattern was formed, and the substrate as an object for exposure,

The projection exposure approach characterized by detecting two or more marks left and formed in the predetermined scanning direction at the criteria member on the 1st stage holding either said mask or said substrates in advance of said scan exposure, respectively.

[Claim 20] The approach according to claim 19 characterized by moving said 1st stage to said scanning direction in order to detect said two or more marks.

[Claim 21] In the projection exposure approach which carries out scan exposure of said substrate using the pattern of said mask by moving synchronously the mask with which the pattern was formed, and the substrate as an object for exposure,

The projection exposure approach characterized by detecting the mark formed in the criteria member on said 1st stage while moving the 1st stage holding either said mask or said substrates to a predetermined scanning direction in advance of said scan exposure.

[Claim 22] Said scanning direction is claims 19 and 20 characterized by what is prescribed by the 1st interferometer systems which measure the positional information of said 1st stage, or an approach given in 21.

[Claim 23] The mark on said criteria member is claims 19 and 20 characterized by being detected with the mark on the 2nd stage holding another side of said mask and said substrates, or an approach given in 21.

[Claim 24] An approach given in any 1 term of claims 19-23 characterized by asking for response relation

with the 2nd system of coordinates for controlling the 1st system of coordinates for controlling migration of said 1st stage, and migration of said 2nd stage using the detection result of the mark on said criteria member.

[Claim 25] It is the approach according to claim 24 characterized by for said 1st system of coordinates being prescribed by the 1st interferometer systems which measure the positional information of said 1st stage, and specifying said 2nd system of coordinates by the 2nd interferometer systems which measure the positional information of said 2nd stage.

[Claim 26] In the projection exposure approach which carries out scan exposure of said substrate by moving synchronously each of the mask with which the pattern was formed, and the substrate as an object for exposure,

The projection exposure approach characterized by to detect two or more marks left to the predetermined scanning direction on the 1st stage holding either said mask or said substrate in advance of said scan exposure, respectively, and to ask for response relation with the 2nd system of coordinates for controlling migration of the 2nd stage holding the 1st system of coordinates for controlling migration of said 1st stage, and another side of said mask and said substrate.

[Claim 27] Said 1st system of coordinates are prescribed by the 1st interferometer systems for measuring the positional information of said 1st stage,

Said 2nd system of coordinates are approaches according to claim 26 characterized by what is prescribed by the 2nd interferometer systems for measuring the positional information of said 2nd stage.

[Claim 28] The mark on said 1st stage is an approach according to claim 26 or 27 characterized by being detected with the mark on said 2nd stage.

[Claim 29] The approach according to claim 28 characterized by arranging two or more marks left to said scanning direction on said 2nd stage.

[Claim 30] The approach according to claim 28 characterized by moving said 1st stage to said predetermined scanning direction in order to detect said two or more marks.

[Claim 31] The approach according to claim 30 characterized by moving said 2nd stage to a different scanning direction from said 1st stage in parallel to migration of said 1st stage in order to detect the mark on said 1st stage, and the mark on said 2nd stage.

[Claim 32] In the projection exposure approach which exposes the substrate held on the 2nd stage using the pattern of the mask held on the 1st stage,

The projection exposure approach characterized by choosing either of the 2nd mode in which a number smaller than the number of the marks detected in the 1st mode in which two or more marks on said 1st stage are detected, and this 1st mode of marks on said 1st stage are detected.

[Claim 33] Said 2nd mode is an approach according to claim 32 characterized by detecting a part of two or more marks detected in said 1st mode.

[Claim 34] The mark on said 1st stage is an approach according to claim 32 or 33 characterized by being detected with the mark on said 2nd stage.

[Claim 35] The approach according to claim 34 characterized by detecting response relation with the 2nd system of coordinates for controlling the 1st system of coordinates for controlling migration for said 1st stage by detecting the mark on said 1st stage, and the mark on said 2nd stage, and migration of said 2nd stage.

[Claim 36] The approach according to claim 35 characterized by scanning [ be / it / under / exposure / of said substrate / synchronization ] said 1st stage and said 2nd stage.

[Claim 37] The approach according to claim 36 characterized by forming two or more marks left to the scanning direction specified by said 1st system of coordinates on said 1st stage.

[Claim 38] The approach according to claim 37 characterized by asking for the parallelism of the scanning direction specified by said 1st system of coordinates by detecting two or more marks on said 1st stage in said 1st mode, and the scanning direction specified by said 2nd system of coordinates.

[Claim 39] The approach according to claim 37 characterized by asking for response relation with the scaling of the scanning direction specified by the scaling and said 2nd system of coordinates of the scanning direction specified by said 1st system of coordinates by detecting two or more marks on said 1st stage in said 1st mode.

[Claim 40] An approach given in any 1 term of claims 32-39 characterized by attaining selection in said 2nd mode after performing said 1st mode.

[Claim 41] The approach according to claim 40 characterized by searching for the drawing error of said mask in said 1st mode, and applying this drawing error to said 2nd mode.



[Claim 42] In the projection aligner which carries out scan exposure of said substrate using the pattern of said mask by moving synchronously each of the mask with which the pattern was formed, and the substrate as an object for exposure,

The 1st stage where holds either said mask or said substrates, and it moves,

The 2nd stage where holds another side of said mask and said substrates, and it moves,

The control system which searches for the information for carrying out scan exposure of said substrate by moving at least one side of said 1st stage and said 2nd stage to a predetermined scanning direction, and displacing relatively said 1st stage and said 2nd stage in advance of said scan exposure,

The projection aligner characterized for preparation \*\*\*\*\* by things.

[Claim 43] The projection system which projects the image of the pattern of said mask on said substrate,

It has further the mark detection system which detects the mark on said 1st stage, and the mark on said 2nd stage through said projection system,

Said control system is equipment according to claim 42 characterized by for said mark detection system detecting the mark on said 1st stage, and the mark on said 2nd stage, and searching for the information for carrying out scan exposure of said substrate while said 1st stage and said 2nd stage are displaced relatively.

[Claim 44] Apart from said mark detection system, it has further an alignment system for detecting the alignment information on said substrate,

On the stage holding said substrate, the mark detected by said mark detection system and the mark detected by said alignment system are arranged,

Said control system is equipment according to claim 43 characterized by searching for the physical relationship of the projection reference point of said projection system, and the detection reference point of said alignment system as information for performing detection by said mark detection system and said alignment system, and carrying out scan exposure of said substrate based on the detection result while said 1st stage and said 2nd stage are displaced relatively.

[Claim 45] The projection reference point of said projection system and the detection reference point of said alignment system are equipment according to claim 44 characterized by being separated to said scanning direction.

[Claim 46] In the projection aligner which carries out scan exposure of said substrate using the pattern of said mask by moving synchronously the mask with which the pattern was formed, and the substrate as an object for exposure,

The criteria member by which two or more reference marks were left and formed in the predetermined scanning direction,

The mark detection system for detecting said reference mark,

The projection aligner characterized by preparation \*\*\*\*\*.

[Claim 47] Equipment according to claim 46 characterized by having a migration means to move said criteria member to said scanning direction in order to detect said two or more reference marks by said mark detection system, respectively.

[Claim 48] In the projection aligner which carries out scan exposure of said substrate using the pattern of said mask by moving synchronously the mask with which the pattern was formed, and the substrate as an object for exposure,

The criteria member in which the reference mark was formed,

The mark detection system for detecting said reference mark,

A migration means to move said criteria member to a predetermined scanning direction in order to detect said reference mark by said mark detection system,

The projection aligner characterized by preparation \*\*\*\*\*.

[Claim 49] Said criteria member is claims 46 and 47 characterized by being prepared on the stage holding either said mask or said substrates, or equipment given in 48.

[Claim 50] In the projection aligner which carries out scan exposure of said substrate by moving each of a mask and a substrate synchronously,

The projection system which projects the image of the pattern of said mask on said substrate,

It has the detection location left towards the synchronized drive of said substrate to the optical axis of this projection system,

The alignment system which detects the alignment information on said substrate,

A measurement means to measure the physical relationship of the projection reference point of said projection system, and the detection reference point of said alignment system,

The projection aligner characterized by preparation \*\*\*\*\*.

[Claim 51] Said measurement means is a criteria member arranged on the stage holding said substrate, Equipment according to claim 50 characterized by having the mark detection system which detects the mark formed in said criteria member through said projection system.

[Claim 52] Said measurement means is equipment according to claim 51 characterized by to measure the physical relationship of the projection reference point of said projection system, and the detection reference point of said alignment system based on the information acquired by detecting the mark on said criteria member through said projection system by said mark detection system, and the information acquired by detecting the mark on said criteria member by said alignment system.

[Claim 53] In the projection aligner which carries out scan exposure of said substrate by carrying out the synchronized drive of the mask with which the pattern was formed, and the substrate as an object for exposure,

The 1st stage holding one body of said mask and said substrate,

The 2nd stage holding the body of another side of said mask and said substrate,

The mark detection system which detects two or more marks on said 1st stage left and arranged towards said synchronized drive in order to ask for response relation with the 2nd system of coordinates for controlling the 1st system of coordinates for controlling migration of said 1st stage, and migration of said 2nd stage in advance of scan exposure of said substrate,

The projection aligner characterized by preparation \*\*\*\*\*.

[Claim 54] In the projection aligner which carries out scan exposure of said substrate by carrying out the synchronized drive of the mask with which the pattern was formed, and the substrate as an object for exposure,

The 1st stage holding one body of said mask and said substrate,

The 2nd stage holding the body of another side of said mask and said substrate,

The projection system which projects the image of the pattern of said mask on said substrate,

The mark detection system which detects two or more marks on said 1st stage left and arranged towards said synchronized drive, respectively,

The alignment system which is prepared apart from said mark detection system, and detects the alignment information on said substrate,

The control system which detects the mark on the stage which holds said substrate by said alignment system, and measures the physical relationship of the projection reference point of said projection system, and the detection reference point of said alignment system based on each detection result while said mark detection system detects the mark on said 1st stage, and the mark on said 2nd stage,

The projection aligner characterized by preparation \*\*\*\*\*.

[Claim 55] In the aligner which exposes a substrate using the pattern of a mask,

The 1st stage holding said mask,

The mark detection system which can detect the mark on said 1st stage,

The control system which chooses whether the 2nd mode in which a number smaller than the number of the marks detected by whether the 1st mode in which said mark detection system detects two or more marks on said 1st stage is performed, and said mark detection system in said 1st mode of marks on said 1st stage are detected is performed,

The aligner characterized by preparation \*\*\*\*\*.

[Claim 56] Said control system is equipment according to claim 55 characterized by choosing said 2nd mode whenever it carries out exposure processing of the substrate of a predetermined number.

[Procedure amendment 3]

[Document to be Amended] Description

[Item(s) to be Amended] 0001

[Method of Amendment] Modification

[Proposed Amendment]

[0001]

[Industrial Application] This invention relates to the projection exposure approach and equipment of for example, a slit scan exposure method.

[Procedure amendment 4]

[Document to be Amended] Description

[Item(s) to be Amended] 0014

[Method of Amendment] Modification

[Proposed Amendment]

[0014] In view of this point, in the projection exposure technique of a slit scan exposure method, this invention reduces the effect of the drawing error of the pattern on reticle (mask), and aims at enabling it to perform matching with a Reticulum label system (mask system of coordinates) and wafer system of coordinates (substrate system of coordinates) to accuracy. Depending on [ accuracy / of the matching ] a process, quick nature may be thought as important about this. Then, this invention aims at enabling it to perform matching with a Reticulum label system (mask system of coordinates) and wafer system of coordinates (substrate system of coordinates) by the high throughput.

[Procedure amendment 5]

[Document to be Amended] Description

[Item(s) to be Amended] 0015

[Method of Amendment] Modification

[Proposed Amendment]

[0015] Furthermore, in the projection exposure technique of a slit scan exposure method, this invention reduces the effect of the drawing error of the pattern on reticle (mask), and aims also at enabling it to measure the amount of base lines which is spacing of the origin/datum of the exposure field of a projection optical system, and the origin/datum of the alignment system of an off-axis method to high degree of accuracy.

[Procedure amendment 6]

[Document to be Amended] Description

[Item(s) to be Amended] 0016

[Method of Amendment] Modification

[Proposed Amendment]

[0016] Moreover, whenever it exchanges the wafer of predetermined number of sheets, when performing base-line measurement, for example, while greater importance may be attached than to correctness to quick nature, it is desirable to perform matching with a Reticulum label system (mask system of coordinates) and wafer system of coordinates (substrate system of coordinates) simultaneously. Then, in case this invention measures the amount of base lines for every predetermined wafer turnover rate, it aims at enabling it to perform matching with a Reticulum label system (mask system of coordinates) and wafer system of coordinates (substrate system of coordinates), and its base-line measurement by the high throughput.

[Procedure amendment 7]

[Document to be Amended] Description

[Item(s) to be Amended] 0023

[Method of Amendment] Modification

[Proposed Amendment]

[0023] Moreover, the 6th projection exposure approach of this invention is set in the same premise section as above-mentioned invention. The alignment system (34) of the off-axis method for detecting the location of the mark for positioning on a substrate (5) near the projection optical system (8) is arranged. Two or more marks for measurement (29A, 29B, --) are formed towards the relative scan on a mask (12). The reference mark member (6) by which two or more reference marks were formed in the mark for measurement of these plurality and the location [ \*\*\*\* / almost ] is arranged on a stage (4). Whenever the reference mark of these plurality consists of the 1st (A [ 35 ], B [ 35 ], --) and 2nd (A [ 37 ], B [ 37 ], --) reference marks formed at spacing corresponding to spacing of the reference point of the projection optical system, and the reference point of the alignment system of the off-axis method and it carries out predetermined number-of-sheets exchange of the substrate (5) Where the 2nd reference mark (37A) on a reference mark member (6) is observed by the alignment system of the off-axis method The amount of location gaps of one predetermined mark for measurement (29A) in two or more marks for measurement on a mask (12) and the 1st corresponding reference mark (35A) is measured. From the measured amount of location gaps, and the amount of location gaps of the 2nd reference mark (37A) observed by the alignment system of the off-axis method, thus, the response relation between the system of coordinates on the mask, and the system of coordinates on the stage, It asks for spacing (the amount of base lines) of the origin/datum in the exposure field of the projection optical system, and the origin/datum of the alignment system of the off-axis method. The 7th projection exposure approach of this invention each of the mask with which the pattern was formed, and the substrate as an object for exposure next, by moving synchronously In the projection exposure approach which carries out scan exposure of the substrate using the pattern of the mask In advance of the scan exposure, the 1st stage and this 1st stage holding the mask by holding the substrate independently, moving at least one side with the 2nd movable stage to a predetermined scanning direction, and moving

relatively on the 1st stage and its 2nd stage The information for carrying out scan exposure of the substrate is searched for. The 8th projection exposure approach of this invention moreover, by moving synchronously the mask with which the pattern was formed, and the substrate as an object for exposure In the projection exposure approach which carries out scan exposure of the substrate using the pattern of the mask, two or more marks left and formed in the predetermined scanning direction at the criteria member on the 1st stage holding either the mask or its substrate are detected in advance of the scan exposure, respectively. The 9th projection exposure approach of this invention moreover, by moving synchronously the mask with which the pattern was formed, and the substrate as an object for exposure While moving the 1st stage holding either the mask or its substrate to a predetermined scanning direction in advance of the scan exposure in the projection exposure approach which carries out scan exposure of the substrate using the pattern of the mask The mark formed in the criteria member on the 1st stage is detected. The 10th projection exposure approach of this invention each of the mask with which the pattern was formed, and the substrate as an object for exposure moreover, by moving synchronously Two or more marks left in advance of the scan exposure in the projection exposure approach which carries out scan exposure of the substrate to the predetermined scanning direction on the 1st stage holding either the mask or its substrate are detected, respectively. It asks for response relation with the 2nd system of coordinates for controlling migration of the 2nd stage holding the 1st system of coordinates and another side of the mask and a substrate for controlling migration of the 1st stage. Moreover, the 11th projection exposure approach of this invention is set to the projection exposure approach which exposes the substrate held on the 2nd stage using the pattern of the mask held on the 1st stage. Either of the 2nd mode in which a number smaller than the number of the marks detected in the 1st mode in which two or more marks on the 1st stage are detected, and this 1st mode of marks on the 1st stage are detected is chosen. The 1st projection aligner of this invention each of the mask with which the pattern was formed, and the substrate as an object for exposure next, by moving synchronously In the projection aligner which carries out scan exposure of the substrate using the pattern of the mask The 1st stage where holds either the mask or its substrate, and it moves, The 2nd stage where holds another side of the mask and its substrate, and it moves, It has the control system which searches for the information for carrying out scan exposure of the substrate by moving at least one side of the 1st stage and its 2nd stage to a predetermined scanning direction, and displacing relatively the 1st stage and its 2nd stage in advance of the scan exposure. Moreover, the 2nd projection aligner of this invention is equipped with the criteria member by which two or more reference marks were left and formed in the predetermined scanning direction in the projection aligner which carries out scan exposure of the substrate, and the mark detection system for detecting the reference mark using the pattern of the mask by moving synchronously the mask with which the pattern was formed, and the substrate as an object for exposure. The 3rd projection aligner of this invention moreover, by moving synchronously the mask with which the pattern was formed, and the substrate as an object for exposure In the projection aligner which carries out scan exposure of the substrate using the pattern of the mask It has the criteria member in which the reference mark was formed, a mark detection system for detecting the reference mark, and a migration means to move the criteria member to a predetermined scanning direction in order to detect the reference mark by the mark detection system. The 4th projection aligner of this invention each of a mask and a substrate moreover, by moving synchronously The projection system which projects the image of the pattern of the mask on the substrate in the projection aligner which carries out scan exposure of the substrate, It has the detection location left towards the synchronized drive of the substrate to the optical axis of this projection system, and has a measurement means to measure the physical relationship of the alignment system which detects the alignment information on the substrate, and the projection reference point and the detection reference point of an alignment system of the projection system. The 5th projection aligner of this invention moreover, by carrying out the synchronized drive of the mask with which the pattern was formed, and the substrate as an object for exposure The 1st stage which holds one body of the mask and its substrate in the projection aligner which carries out scan exposure of the substrate, The 2nd stage holding the body of another side of the mask and its substrate and scan exposure of the substrate are preceded. In order to ask for response relation with the 2nd system of coordinates for controlling the 1st system of coordinates for controlling migration of the 1st stage, and migration of the 2nd stage, it has the mark detection system which detects two or more marks on the 1st stage left and arranged towards the synchronized drive. The 6th projection aligner of this invention moreover, by carrying out the synchronized drive of the mask with which the pattern was formed, and the substrate as an object for exposure The 1st stage which holds one body of the mask and its substrate in the projection aligner which carries out scan exposure of the substrate, The 2nd stage holding the body of another side of the mask and its substrate, and the projection system which projects the image of the pattern of the mask on the substrate,

The mark detection system which detects two or more marks on the 1st stage left and arranged towards the synchronized drive, respectively, While the alignment system which is prepared apart from the mark detection system, and detects the alignment information on the substrate, and its mark detection system detect the mark on the 1st stage, and the mark on the 2nd stage The mark on the stage which holds the substrate by the alignment system is detected, and it has the control system which measures the physical relationship of the projection reference point and the detection reference point of an alignment system of the projection system based on each detection result. Moreover, the aligner of this invention is set to the aligner which exposes a substrate using the pattern of a mask. The 1st stage holding the mask, and the mark detection system which can detect the mark on the 1st stage, [ whether the 1st mode in which the mark detection system detects two or more marks on the 1st stage is performed, and ] It has the control system which chooses whether the 2nd mode in which a number smaller than the number of the marks detected by the mark detection system in the 1st mode of marks on the 1st stage are detected is performed.

[Procedure amendment 8]

[Document to be Amended] Description

[Item(s) to be Amended] 0029

[Method of Amendment] Modification

[Proposed Amendment]

[0029]

[Example] Hereafter, with reference to a drawing, it explains per 1st example of this invention. This example applies this invention, when exposing the pattern of reticle on a wafer with the projection aligner of a slit scan exposure method. Drawing 1 shows the projection aligner of this example, the pattern on reticle 12 is illuminated by the lighting field (henceforth a "slit-like lighting field") of the rectangle by the exposure light EL from the illumination-light study system by which the graphic display abbreviation was carried out in this drawing 1, and projection exposure of the image of that pattern is carried out on a wafer 5 through a projection optical system 8. In this case, synchronizing with reticle 12 being scanned with constant speed V forward to the space of drawing 1, a wafer 5 is scanned backward to the space of drawing 1 to the lighting field of the shape of a slit of the exposure light EL by constant speed V/M (1/M is the cutback scale factor of a projection optical system 8).

[Procedure amendment 9]

[Document to be Amended] Description

[Item(s) to be Amended] 0122

[Method of Amendment] Modification

[Proposed Amendment]

[0122] Moreover, although the technique of the above-mentioned example is explained about the base-line measurement at the time of the alignment of an off-axis method, it can expect the same effectiveness by application of this invention also in the TTL (through THE lens) method using the inside of the field of a projection optical system. Thus, this invention is not limited to the above-mentioned example, but can take configurations various in the range which does not deviate from the summary of this invention. Moreover, according to the above-mentioned projection exposure approach, the effect of the drawing error of the mark for measurement on a mask can be small suppressed by asking for the parameter (offset of a scale factor, the scaling of a scanning direction, a revolution, the parallelism of a scanning direction, the direction of X, and the direction of Y) which matches mask system of coordinates and substrate system of coordinates by the least squares approximation etc. according to the location gap called for eventually in each location of two or more marks for measurement on a mask. Moreover, according to the above-mentioned projection aligner, by equalizing the measurement result about two or more marks for measurement by the side of a mask, the drawing error of the mark for measurement of a mask is made small, and the amount of base lines which is spacing of the origin/datum of a projection optical system and the origin/datum of an alignment system can be measured to accuracy. Moreover, it is while according to the above-mentioned projection aligner making it correspond to two or more marks for measurement on a mask and forming two or more the 1st reference mark on a reference mark member, Since two or more the 2nd reference mark is formed from the 1st reference mark of these plurality at spacing corresponding to spacing of the reference point in the exposure field of a projection optical system, and the reference point of the alignment system of an off-axis method, respectively, and equalization is performed also for a reference mark side, the amount of base lines is measured more by accuracy. Moreover, according to the above-mentioned projection exposure approach, it can ask for the response relation between the system of coordinates on a mask, and the system of coordinates on a stage by the high throughput by choosing the simple measurement process by quick mode

if needed. Moreover, according to the above-mentioned projection exposure approach, the response relation and the amount of base lines of the system of coordinates on a mask and the system of coordinates on a stage can be calculated by the high throughput by choosing the simple measurement process by quick mode if needed. Moreover, according to the above-mentioned projection exposure approach, when exposing by the scanning method continuously to many substrates since the simple measurement process by quick mode is performed whenever it exposes to the substrate of predetermined number of sheets, the response relation and the amount of base lines of the system of coordinates on a mask and the system of coordinates on a stage can be calculated by the high throughput.

[Procedure amendment 10]

[Document to be Amended] Description

[Item(s) to be Amended] 0123

[Method of Amendment] Modification

[Proposed Amendment]

[0123]

[Effect of the Invention] According to this invention, the effect of the drawing error of the mark for measurement on a mask can be suppressed small.

[Procedure amendment 11]

[Document to be Amended] Description

[Item(s) to be Amended] 0124

[Method of Amendment] Modification

[Proposed Amendment]

[0124] Moreover, according to this invention, the amount of base lines which is spacing of the origin/datum of a projection optical system and the origin/datum of an alignment system is measurable to accuracy.

[Procedure amendment 12]

[Document to be Amended] Description

[Item(s) to be Amended] 0125

[Method of Amendment] Modification

[Proposed Amendment]

[0125] Moreover, according to this invention, it can ask for the response relation between the system of coordinates on a mask, and the system of coordinates on a stage by the high throughput.

[Procedure amendment 13]

[Document to be Amended] Description

[Item(s) to be Amended] 0126

[Method of Amendment] Modification

[Proposed Amendment]

[0126] Moreover, according to this invention, the amount of base lines can be calculated by the high throughput.

[Procedure amendment 14]

[Document to be Amended] Description

[Item(s) to be Amended] drawing 1

[Method of Amendment] Modification

[Proposed Amendment]

[Drawing 1] It is the block diagram showing the projection aligner of one example of this invention.

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[Translation done.]

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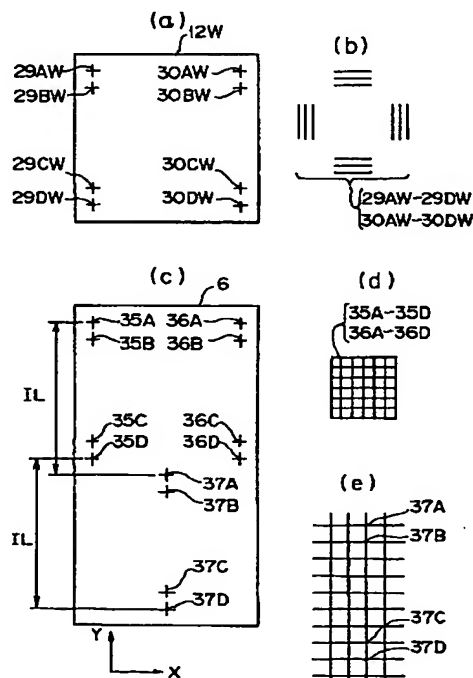
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(54) 【発明の名称】 投影露光方法

(57) 【要約】

【目的】 スリットスキャン方式で露光する際に、レチクルの描画誤差の影響を低減させて、レチクル座標系とウエハ座標系との対応付けを正確に行う。

【構成】 レチクルの投影像 12W 上に、走査方向に2列のアライメントマーク像 29AW~29DW 及び 30AW~30DW が投影され、ウエハステージ側の基準マーク板 6 上にも走査方向に2列の基準マーク 35A~35D 及び 36A~36D が形成されている。レチクル及び基準マーク板 6 を走査方向に移動して、レチクルアライメント顕微鏡により、マーク像 29AW、30AW と基準マーク 35A、36A との誤差を求め、同様に他のマーク像と基準マークとの誤差を求め、それらの誤差に座標計測系の計測誤差の補正を行って、レチクル座標系とウエハ座標系との間の変換パラメータを求める。





## 【特許請求の範囲】

【請求項 1】 照明光で所定形状の照明領域を照明し、前記所定形状の照明領域内のマスク上のパターン像を投影光学系を介してステージ上の基板に露光し、前記所定形状の照明領域に対して相対的に前記マスク及び前記基板を同期して走査することにより、前記マスク上の前記所定形状の照明領域よりも広い面積のパターン像を前記基板上に露光する方法において、前記マスク上に前記相対的な走査の方向に複数の計測用マークを形成し、該複数の計測用マークとほぼ共役な位置に複数の基準マークが形成された基準マーク部材を前記ステージ上に配置し、前記マスク及び前記基板を前記相対的な走査の方向に同期して移動させて、前記マスク上の複数の計測用マークの内の 1 つの計測用マークと前記ステージ上の対応する基準マークとの位置ずれ量を順次計測し、前記複数の計測用マークと前記複数の基準マークとのそれぞれの位置ずれ量より、前記マスク上の座標系と前記ステージ上の座標系との対応関係を求めることを特徴とする投影露光方法。

【請求項 2】 照明光で所定形状の照明領域を照明し、前記所定形状の照明領域内のマスク上のパターン像を投影光学系を介してステージ上の基板に露光し、前記所定形状の照明領域に対して相対的に前記マスク及び前記基板を同期して走査することにより、前記マスク上の前記所定形状の照明領域よりも広い面積のパターン像を前記基板上に露光する方法において、前記投影光学系の近傍に前記基板上の位置決め用のマークの位置を検出するためのオフ・アクシス方式のアライメント系を配置し、前記マスク上に前記相対的な走査の方向に複数の計測用マークを形成し、前記投影光学系の露光フィールド内の基準点と前記オフ・アクシス方式のアライメント系の基準点との間隔に対応する間隔で第 1 及び第 2 の基準マークが形成された基準マーク部材を前記ステージ上に配置し、前記オフ・アクシス方式のアライメント系で前記基準部材上の前記第 2 の基準マークを観察した状態で、前記マスクを前記相対的な走査の方向に移動させて、前記マスク上の複数の計測用マークの内の 1 つの計測用マークと前記ステージ上の前記第 1 の基準マークとの位置ずれ量を順次計測し、前記複数の計測用マークと前記第 1 の基準マークとのそれぞれの位置ずれ量の平均値及び前記オフ・アクシス方式のアライメント系で観察した前記第 2 の基準マークの位置ずれ量より、前記投影光学系の露光フィールド内の基準点と前記オフ・アクシス方式のアライメント系の基準点との間隔を求めることを特徴とする投影露光方法。

【請求項 3】 前記基準マーク部材上に、前記マスク上の複数の計測用マークに対応させて前記第 1 の基準マークを複数個形成すると共に、該複数の第 1 の基準マーク

からそれぞれ前記投影光学系の露光フィールド内の基準点と前記オフ・アクシス方式のアライメント系の基準点との間隔に対応する間隔で前記第 2 の基準マークを複数個形成し、

前記マスク及び前記ステージを前記相対的な走査の方向に同期して移動させて、前記マスク上の複数の計測用マークの内の 1 つの計測用マークと前記ステージ上の対応する前記第 1 の基準マークとの位置ずれ量を順次計測すると共に、前記オフ・アクシス方式のアライメント系で複数の前記第 2 の基準マークの内の対応する基準マークを観察し、

前記複数の計測用マークと前記複数の第 1 の基準マークとのそれぞれの位置ずれ量の平均値及び前記オフ・アクシス方式のアライメント系で観察した前記複数の第 2 の基準マークの位置ずれ量の平均値より、前記投影光学系の露光フィールド内の基準点と前記オフ・アクシス方式のアライメント系の基準点との間隔を求めることを特徴とする請求項 2 記載の投影露光方法。

【請求項 4】 照明光で所定形状の照明領域を照明し、前記所定形状の照明領域内のマスク上のパターン像を投影光学系を介してステージ上の基板に露光し、前記所定形状の照明領域に対して相対的に前記マスク及び前記基板を同期して走査することにより、前記マスク上の前記所定形状の照明領域よりも広い面積のパターン像を前記基板上に露光する方法において、

前記マスク上に前記相対的な走査の方向に複数の計測用マークを形成し、該複数の計測用マークとほぼ共役な位置に複数の基準マークが形成された基準マーク部材を前記ステージ上に配置し、

前記マスク及び前記基板を前記相対的な走査の方向に同期して移動させて、前記マスク上の複数の計測用マークの内の 1 つの計測用マークと前記ステージ上の対応する基準マークとの位置ずれ量を順次計測し、前記計測用マークと前記基準マークとのそれぞれの位置ずれ量を求める第 1 工程と；前記マスク上の複数の計測用マークの内の所定の 1 つの計測用マークと前記ステージ上の対応する基準マークとの位置ずれ量を 1 回だけ計測し、前記計測用マークと前記基準マークとの位置ずれ量を求める第 2 工程と；前記第 1 工程と前記第 2 工程とのどちらか一方を選択し、選択された工程で求められた前記計測用マークと前記基準マークとのそれぞれの位置ずれ量に基づいて前記マスク上の座標系と前記ステージ上の座標系との対応関係を求める第 3 工程と；を有することを特徴とする投影露光方法。

【請求項 5】 照明光で所定形状の照明領域を照明し、前記所定形状の照明領域内のマスク上のパターン像を投影光学系を介してステージ上の基板に露光し、前記所定形状の照明領域に対して相対的に前記マスク及び前記基板を同期して走査することにより、前記マスク上の前記所定形状の照明領域よりも広い面積のパターン像を前記



基板上に露光する方法において、  
前記投影光学系の近傍に前記基板上の位置決め用のマークの位置を検出するためのオフ・アクシス方式のアライメント系を配置し、  
前記マスク上に前記相対的な走査の方向に複数の計測用マークを形成し、該複数の計測用マークとほぼ共役な位置に複数の基準マークが形成された基準マーク部材を前記ステージ上に配置し、該複数の基準マークは前記投影光学系の基準点と前記オフ・アクシス方式のアライメント系の基準点との間隔に対応する間隔で配置された第 1 及び第 2 の基準マークからなり、  
前記オフ・アクシス方式のアライメント系で前記基準マーク部材上の前記第 2 の基準マークを観察した状態で、前記マスクを前記相対的な走査の方向に移動させて、前記マスク上の複数の計測用マークの内の 1 つの計測用マークと前記第 1 の基準マークとの位置ずれ量を順次計測する第 1 工程と；前記オフ・アクシス方式のアライメント系で前記基準マーク部材上の前記第 2 の基準マークを観察した状態で、前記マスク上の複数の計測用マークの内の所定の 1 つの計測用マークと前記第 1 の基準マークとの位置ずれ量を計測する第 2 工程と；前記第 1 工程と前記第 2 工程とのどちらか一方を選択する第 3 工程と；該第 3 工程で選択された工程での計測結果である、前記計測用マークと前記基準マークとのそれぞれの位置ずれ量、及び前記オフ・アクシス方式のアライメント系で観察した前記第 2 の基準マークの位置ずれ量より、前記マスク上の座標系と前記ステージ上の座標系との対応関係と、前記投影光学系の露光フィールド内の基準点と前記オフ・アクシス方式のアライメント系の基準点との間隔を求める第 4 工程と；を有することを特徴とする投影露光方法。

【請求項 6】 照明光で所定形状の照明領域を照明し、前記所定形状の照明領域内のマスク上のパターン像を投影光学系を介してステージ上の基板上に露光し、前記所定形状の照明領域に対して相対的に前記マスク及び前記基板を同期して走査することにより、前記マスク上の前記所定形状の照明領域よりも広い面積のパターン像を前記基板上に露光する方法において、  
前記投影光学系の近傍に前記基板上の位置決め用のマークの位置を検出するためのオフ・アクシス方式のアライメント系を配置し、  
前記マスク上に前記相対的な走査の方向に複数の計測用マークを形成し、該複数の計測用マークとほぼ共役な位置に複数の基準マークが形成された基準マーク部材を前記ステージ上に配置し、該複数の基準マークは前記投影光学系の基準点と前記オフ・アクシス方式のアライメント系の基準点との間隔に対応する間隔で形成された第 1 及び第 2 の基準マークからなり、  
前記基板を所定枚数交換する毎に、  
前記オフ・アクシス方式のアライメント系で前記基準マ

ーク部材上の前記第 2 の基準マークを観察した状態で、前記マスク上の複数の計測用マークの内の所定の 1 つの計測用マークと対応する前記第 1 の基準マークとの位置ずれ量を計測し、該計測された位置ずれ量、及び前記オフ・アクシス方式のアライメント系で観察した前記第 2 の基準マークの位置ずれ量より、前記マスク上の座標系と前記ステージ上の座標系との対応関係と、前記投影光学系の露光フィールド内の基準点と前記オフ・アクシス方式のアライメント系の基準点との間隔を求めることを特徴とする投影露光方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】 本発明は、例えばスリットスキャン露光方式の投影露光装置に適用して好適な投影露光方法に関する。

【0002】

【従来の技術】 半導体素子、液晶表示素子又は薄膜磁気ヘッド等をフォトリソグラフィ工程で製造する際に、フォトマスク又はレチクル（以下、「レチクル」と総称する）のパターンを感光材が塗布された基板（ウエハ、ガラスプレート等）上に転写する投影露光装置が使用されている。従来の投影露光装置としては、ウエハの各ショット領域を順次投影光学系の露光フィールド内に移動させて、各ショット領域に順次レチクルのパターン像を露光するというステップ・アンド・リピート方式の縮小投影型露光装置（ステッパー）が多く使用されていた。

【0003】 図 18 は従来のステッパーの要部を示し、この図 18 において、ウエハステージ 4 の上にウエハ 5 が載置され、このウエハ 5 の近傍のウエハステージ 4 上に基準マーク板 57 が固定されている。そして、図示省略された照明光学系からの露光光のもとで、レチクル 12 上のパターンの像が投影光学系 8 を介してウエハ 5 上の各ショット領域に投影露光される。この際、ウエハステージ 4 はウエハ座標系に沿って駆動されるので、レチクル 12 のウエハ座標系上での位置及びレチクル 12 のウエハ座標系に対する回転角を計測しておく必要がある。そのために、レチクル 12 のパターン領域の近傍には対向するように 2 個のアライメントマーク（レチクルマーク）60R 及び 61R が形成され、基準マーク板 57 上には、それらレチクルマーク 60R 及び 61R のウエハ 5 上での設計上の間隔と等しい間隔で 2 個の基準マーク 60F 及び 61F が形成されている。

【0004】 また、レチクル 12 のレチクルマーク 60R 及び 61R の上にはそれぞれレチクルアライメント顕微鏡 58 及び 59 が配置されている。レチクルアライメント顕微鏡 58 及び 59 はそれぞれ、露光光と同じ波長のアライメント光を射出する照明光源と、レチクル 12 上のレチクルマークとウエハ 5 上のアライメントマーク（ウエハマーク）又は基準マーク板 57 上の基準マークとを同時に観察できるセンサーとを備えている。図 18

のステッパでウエハ 5 への露光を行う際には、順次ウエハステージ 4 のみをステップ・アンド・リピート方式で移動することによって、ウエハ 5 の各ショット領域にレチクル 1 2 上のパターンの像がそれぞれ露光される。

【0005】斯かるステッパにおいて、前工程で形成されたウエハ 5 上の回路パターンの上に更にレチクル 1 2 のパターン像を露光するような場合には、ウエハ 5 上の各ショット領域の座標を規定するウエハ座標系と、レチクル 1 2 上のパターンの座標を規定するレチクル座標系との対応を取る（即ちアライメントを行う）必要がある。ステッパの場合には、投影光学系 8 の露光フィールドとウエハ 5 上の 1 ショット領域の大きさが等しく、露光する際にレチクル 1 2 を駆動する必要がないため、ウエハ座標系とレチクル座標系の対応を以下のようにして取っていた。

【0006】即ち、ウエハステージ 4 を駆動して基準マーク板 5 7 を投影光学系 8 の露光フィールド内に移動させた後、一方のレチクルアライメント顕微鏡 5 8 によってレチクルマーク 6 0 R と基準マーク 6 0 F との位置ずれ量を検出し、他方のレチクルアライメント顕微鏡 5 9 によってレチクルマーク 6 1 R と基準マーク 6 1 F との位置ずれ量を検出して、それら位置ずれ量からウエハ座標系上でのレチクル 1 2 のパターンの位置を求めている。更に、基準マーク 6 0 F を基準マーク 6 1 F の位置に移動して、レチクルアライメント顕微鏡 5 9 によってレチクルマーク 6 1 R と基準マーク 6 0 F との位置ずれ量を検出することによって、ウエハ座標系上でのレチクル 1 2 の回転角を計測していた。そして、レチクル 1 2 又はウエハステージ 4 を回転させてその回転角を補正することによって、最終的にウエハ座標系とレチクル座標系との対応付けを行っていた。

【0007】また、図 1 8 においては、ウエハ 5 上の各ショット領域に対応して形成された各アライメントマーク（ウエハマーク）の位置を検出するために、投影光学系 8 の側面部にオフ・アクシス方式のアライメント顕微鏡 3 4 が設けられている。この場合、このアライメント顕微鏡 3 4 で検出されたウエハマークの位置に基づいて、対応するウエハ 5 上のショット領域が投影光学系 8 の露光フィールド内に設定される。従って、予め投影光学系 8 の露光フィールド内の基準点（例えば露光中心）と、オフ・アクシス方式のアライメント顕微鏡 3 4 の観察領域の基準点 6 2 との間隔である所謂ベースライン量を求めておく必要がある。

【0008】従来のステッパにおいて、そのようなベースライン量を計測する際には、レチクルマーク 6 0 R、6 1 R と基準マーク 6 0 F、6 1 F の共役像との位置ずれ量を計測した後に、例えばベースライン量の設計値に等しい量だけウエハステージ 4 を移動させて、アライメント顕微鏡 3 4 によりその基準点 6 2 と基準マーク板 5 7 上の対応する基準マークとの位置ずれ量を計測し

ていた。それらの位置ずれ量からベースライン量が求められていた。

【0009】

【発明が解決しようとする課題】近年、半導体素子等においてはパターンが微細化しているため、投影光学系の解像力を高めることが求められている。解像力を高めるための手法には、露光光の波長の短波長化、又は投影光学系の開口数の増大等の手法があるが、何れの手法を用いる場合でも、従来例と同じ程度の露光フィールドを確保しようすると、露光フィールドの全面で結像性能（ディストーション、像面湾曲等）を所定の精度に維持することが困難になってきている。そこで現在見直されているのが、所謂スリットスキャン露光方式の投影露光装置である。

【0010】このスリットスキャン露光方式の投影露光装置では、矩形状又は円弧状等の照明領域（以下、「スリット状の照明領域」という）に対してレチクル及びウエハを相対的に同期して走査しながら、そのレチクルのパターンがウエハ上に露光される。従って、ステッパ方式と同じ面積のパターンをウエハ上に露光するとすれば、スリットスキャン露光方式では、ステッパ方式に比べて投影光学系の露光フィールドを小さくすることができ、露光フィールド内での結像性能の精度が向上する可能性がある。

【0011】また、従来のレチクルの大きさの主流は 6 インチサイズであり、投影光学系の投影倍率の主流は 1/5 倍であったが、半導体素子等の回路パターンの大面積化により、倍率 1/5 倍のもとでのレチクルの大きさは 6 インチサイズでは間に合わなくなっている。そのため、投影光学系の投影倍率を例えば 1/4 倍に変更した投影露光装置を設計する必要がある。そして、このような被転写パターンの大面積化に応えるためにも、スリットスキャン露光方式が有利である。

【0012】斯かるスリットスキャン露光方式の投影露光装置において、従来のステッパで用いられていたレチクル座標系とウエハ座標系との対応付けの手法を適用すると、投影倍率が 1/4 倍になったことから、レチクル上の回路パターンの描画誤差によってアライメント精度が劣化するという不都合がある。更に、特願平 3-169781 号では、ステッパにおいてウエハステージを移動させることなく、複数の計測用マークの位置ずれ量を同時に計測することにより、レチクルの回転角を計測する技術が提案されている。しかしながら、この複数の計測用マークの同時計測による回転角の計測という概念は、スリットスキャン露光方式の投影露光装置の走査方向には利用できず、レチクル座標系とウエハ座標系との回転角及びそれら座標系の座標直交度が精度よく計測できないという不都合があった。

【0013】また、投影光学系の露光フィールド内の基準位置と、オフ・アクシス方式のアライメント系の基準

位置との間隔であるベースライン量の計測方法に関して、従来のステッパーにおけるレチクル上の1箇所（2個の）のマークを用いる計測方法をそのままスリットスキャン露光方式の投影露光装置に適用したのでは、レチクルの描画誤差の影響を大きく受けるという不都合がある。

【0014】本発明は斯かる点に鑑み、スリットスキャン露光方式の投影露光装置において、レチクル（マスク）上のパターンの描画誤差の影響を低減させて、レチクル座標系（マスク座標系）とウエハ座標系（基板座標系）との対応付けを正確に行える投影露光方法を提供することを目的とする。これに関して、工程によってはその対応付けの正確さよりも迅速性が重視される場合がある。そこで、本発明はレチクル座標系（マスク座標系）とウエハ座標系（基板座標系）との対応付けを高いスループットで行う投影露光方法を提供することを目的とする。

【0015】更に、本発明は、スリットスキャン露光方式の投影露光装置において、レチクル（マスク）上のパターンの描画誤差の影響を低減させて、投影光学系の露光フィールドの基準点と、オフ・アクシス方式のアライメント系の基準点との間隔であるベースライン量の計測を高精度に行える投影露光方法を提供することを目的とする。

【0016】また、例えばベースライン計測を所定枚数のウエハを交換する毎に行うような場合には、正確さよりも迅速性が重視されることがあると共に、同時にレチクル座標系（マスク座標系）とウエハ座標系（基板座標系）との対応付けを行うことが望ましい。そこで、本発明はベースライン量の計測を所定のウエハ交換回数毎に行う際、レチクル座標系（マスク座標系）とウエハ座標系（基板座標系）との対応付け、及びそのベースライン計測を高いスループットで行う投影露光方法を提供することを目的とする。

【0017】

【課題を解決するための手段】本発明による第1の投影露光方法は、照明光で所定形状の照明領域を照明し、前記所定形状の照明領域内のマスク（12）上のパターン像を投影光学系（8）を介してステージ（4）上の基板（5）に露光し、その所定形状の照明領域に対して相対的にマスク（12）及び基板（5）を同期して走査することにより、マスク（12）上のその所定形状の照明領域よりも広い面積のパターン像を基板（5）上に露光する方法において、マスク（12）上にその相対的な走査の方向に複数の計測用マーク（29A～29D）を形成し、これら複数の計測用マークとほぼ共役な位置に複数の基準マーク（35A～35D）が形成された基準マーク部材（6）をステージ（4）上に配置し、マスク（12）及び基板（5）をその相対的な走査の方向に同期して移動させて、マスク（12）上の複数の計測用マーク

の内の1つの計測用マーク（29A, 29B, ……）とステージ（4）上の対応する基準マーク（35A, 35B, ……）との位置ずれ量を順次計測し、それら複数の計測用マークとそれら複数の基準マークとのそれぞれの位置ずれ量より、マスク（12）上の座標系とステージ（4）上の座標系との対応関係を求めるものである。

【0018】また、本発明による第2の投影露光方法は、上述の発明と同じ前提部において、投影光学系（8）の近傍に基板（5）上の位置決め用のマークの位置を検出するためのオフ・アクシス方式のアライメント系（34）を配置し、マスク（12）上にその相対的な走査の方向に複数の計測用マーク（29A～29D）を形成し、投影光学系（8）の露光フィールド内の基準点とオフ・アクシス方式のアライメント系（34）の基準点との間隔に対応する間隔で第1の基準マーク（35A）及び第2の基準マーク（37A）が形成された基準マーク部材（6）をステージ（4）上に配置する。

【0019】そして、オフ・アクシス方式のアライメント系（34）で基準部材（6）上の第2の基準マーク（37A）を観察した状態で、マスク（12）を前記相対的な走査の方向に移動させて、マスク（12）上の複数の計測用マークの内の1つの計測用マーク（29A, 29B, ……）とステージ（4）上の第1の基準マーク（35A）との位置ずれ量を順次計測し、それら複数の計測用マークとそれら第1の基準マークとのそれぞれの位置ずれ量の平均値及びオフ・アクシス方式のアライメント系（34）で観察したその第2の基準マークの位置ずれ量より、投影光学系（8）の露光フィールド内の基準点とオフ・アクシス方式のアライメント系（34）の基準点との間隔を求めるものである。

【0020】また、本発明の第3の投影露光方法は、その第2の投影露光方法において、基準マーク部材（6）上に、マスク（12）上の複数の計測用マーク（29A～29D）に対応させてその第1の基準マークを複数個（35A～35D）形成すると共に、これら複数の第1の基準マーク（35A～35D）からそれぞれ投影光学系（8）の露光フィールド内の基準点とオフ・アクシス方式のアライメント系（34）の基準点との間隔に対応する間隔でその第2の基準マークを複数個（37A～37D）形成し、マスク（12）及びステージ（4）をその相対的な走査の方向に同期して移動させて、マスク（12）上の複数の計測用マークの内の1つの計測用マーク（29A, 29B, ……）とステージ（4）上の対応する第1の基準マーク（35A, 35B, ……）との位置ずれ量を順次計測すると共に、オフ・アクシス方式のアライメント系（34）で複数の第2の基準マークの内の対応する基準マーク（37A, 37B, ……）を観察し、それら複数の計測用マークとそれら複数の第1の基準マークとのそれぞれの位置ずれ量の平均値及びオフ・アクシス方式のアライメント系（34）で観察したそ

れら複数の第2の基準マークの位置ずれ量の平均値より、投影光学系(8)の露光フィールド内の基準点とオフ・アクシス方式のアライメント系(34)の基準点との間隔を求めるものである。

【0021】次に、本発明の第4の投影露光方法は、上述の発明と同じ前提部において、上述の第1の投影露光方法と同様に、マスク(12)上の複数の計測用マーク(29A, 29B, ...)と対応する基準マーク(35A, 35B, ...)とのそれぞれの位置ずれ量を求める第1工程と；そのマスク上の複数の計測用マークの内の所定の1つの計測用マーク(29A)とそのステージ上の対応する基準マーク(35A)との位置ずれ量を1回だけ計測し、計測用マーク(29A)と基準マーク(35A)との位置ずれ量を簡易的に求める第2工程と；その第1工程とその第2工程とのどちらか一方を選択し、この選択された工程で求められたその計測用マークとその基準マークとのそれぞれの位置ずれ量に基づいてマスク(12)上の座標系とステージ(4)上の座標系との対応関係を求める第3工程と；を有するものである。

【0022】また、本発明の第5の投影露光方法は、上述の発明と同じ前提部において、上述の第2の投影露光方法と同様に、オフ・アクシス方式のアライメント系で基準マーク部材(6)上の第2の基準マーク(37A, 37B, ...)を観察した状態で、マスク(12)をその相対的な走査の方向に移動させて、マスク(12)上の複数の計測用マーク(29A, 29B, ...)の内の1つの計測用マークと第1の基準マーク(35A, 35B, ...)との位置ずれ量を順次計測する第1工程と；オフ・アクシス方式のアライメント系で基準マーク部材(6)上の第2の基準マーク(37A)を観察した状態で、マスク(12)上の複数の計測用マークの内の所定の1つの計測用マーク(29A)と第1の基準マーク(35A)との位置ずれ量を簡易的に計測する第2工程と；それら第1工程と第2工程とのどちらか一方を選択する第3工程と；この第3工程で選択された工程での計測結果である、その計測用マークとその基準マークとの位置ずれ量、及びそのオフ・アクシス方式のアライメント系で観察した第2の基準マークの位置ずれ量より、そのマスク上の座標系とそのステージ上の座標系との対応関係と、その投影光学系の露光フィールド内の基準点とそのオフ・アクシス方式のアライメント系の基準点との間隔(ベースライン量)を求める第4工程と；を有するものである。

【0023】また、本発明の第6の投影露光方法は、上述の発明と同じ前提部において、投影光学系(8)の近傍に基板(5)上の位置決め用のマークの位置を検出するためのオフ・アクシス方式のアライメント系(34)を配置し、マスク(12)上にその相対的な走査の方向に複数の計測用マーク(29A, 29B, ...)を形成し、これら複数の計測用マークとほぼ共役な位置に複数

の基準マークが形成された基準マーク部材(6)をステージ(4)上に配置し、これら複数の基準マークはその投影光学系の基準点とそのオフ・アクシス方式のアライメント系の基準点との間隔に対応する間隔で形成された第1(35A, 35B, ...)及び第2(37A, 37B, ...)の基準マークからなり、基板(5)を所定枚数交換する毎に、そのオフ・アクシス方式のアライメント系で基準マーク部材(6)上の第2の基準マーク(37A)を観察した状態で、マスク(12)上の複数の計測用マークの内の所定の1つの計測用マーク(29A)と対応する第1の基準マーク(35A)との位置ずれ量を計測し、このように計測された位置ずれ量、及びそのオフ・アクシス方式のアライメント系で観察した第2の基準マーク(37A)の位置ずれ量より、そのマスク上の座標系とそのステージ上の座標系との対応関係と、その投影光学系の露光フィールド内の基準点とそのオフ・アクシス方式のアライメント系の基準点との間隔(ベースライン量)を求めるものである。

【0024】

【作用】斯かる本発明の第1の投影露光方法に於いては、マスク(12)上に複数の計測用マークを配置し、それらの計測用マークとほぼ共役な基準マークを基準マーク部材(6)上に配置し、マスク(12)及びステージ(4)をステッピング方式で送りながら、それぞれのマークの位置ずれが計測される。そして、最終的に、例えば各位置で求められた位置ずれに合わせて、最小自乗近似等によって、マスク座標系と基板座標系とを対応付けるパラメータ(倍率、走査方向のスケール、回転、走査方向の平行度、X方向及びY方向のオフセット)を求めることにより、マスク(12)上の計測用マークの描画誤差の影響を小さく抑えることができる。また、相対的な走査の方向のマーク計測は順次別々に行われるので非同時計測となるが、複数箇所で計測する為、平均化効果があり、高精度計測が可能となる。

【0025】また、第2の投影露光方法によれば、マスク(12)側の複数の計測用マークに関する計測結果を平均化することにより、マスク(12)の計測用マークの描画誤差の影響を小さくして、投影光学系(8)の基準点とアライメント系(34)の基準点との間隔であるベースライン量を正確に計測できる。また、第3の投影露光方法によれば、基準マーク部材(6)上に、マスク(12)上の複数の計測用マーク(29A~29D)に対応させてその第1の基準マークを複数個(35A~35D)形成すると共に、これら複数の第1の基準マーク(35A~35D)からそれぞれ投影光学系(8)の露光フィールド内の基準点とオフ・アクシス方式のアライメント系(34)の基準点との間隔に対応する間隔でその第2の基準マークを複数個(37A~37D)形成しているため、基準マーク側でも平均化が行われるので、より正確にベースライン量が計測される。

【0026】次に、本発明の第4の投影露光方法によれば、高いスループットを要求される場合には、第2工程を選択して計測用マーク(29A)と基準マーク(35A)との位置ずれ量を1回だけ計測し、高精度が要求される場合には第1工程を実行することにより、迅速性に対する要求をも満たすことができる。この場合、第1工程において、更に予め計測用マーク(29A)の本来の位置からの位置ずれ量(これを「マーク誤差」と呼ぶ)を求めて記憶しておき、第2工程を実行した場合にはそのマーク誤差の補正を行うことにより、高いスループットと高精度との両方の要求に応えることができる。

【0027】同様に、第5の投影露光方法によれば、高いスループットを要求される場合には、第2工程を選択してアライメント系(34)で第2の基準マーク(37A)を観察した状態で、1つの計測用マーク(29A)と第1の基準マーク(35A)との位置ずれ量を1回だけ計測し、高精度が要求される場合には第1工程を実行することにより、迅速性に対する要求をも満たすことができる。この場合、第1工程において、更に予めマーク誤差を求めて記憶しておき、第2工程を実行した場合にはそのマーク誤差の補正を行うことにより、高いスループットと高精度との両方の要求に応えることができる。

【0028】また、第6の投影露光方法によれば、基板(5)を所定枚数交換する毎に、即ち所定枚数の基板(5)に露光する毎に、オフ・アクシス方式のアライメント系(34)で第2の基準マーク(37A)を観察した状態で、1つの計測用マーク(29A)と第1の基準マーク(35A)との位置ずれ量を1回だけ計測し、この計測結果よりマスク上の座標系とステージ上の座標系との対応関係と、ベースライン量とを求める。従って、高いスループットで計測が行われる。

【0029】

【実施例】以下、本発明による投影露光方法の第1実施例につき図面を参照して説明する。本実施例は、スリットスキャン露光方式の投影露光装置でレチクルのパターンをウエハ上に露光する場合に、本発明を適用したものである。図1は本実施例の投影露光装置を示し、この図1において、図示省略された照明光学系からの露光光ELによる矩形的照明領域(以下、「スリット状の照明領域」という)によりレチクル12上のパターンが照明され、そのパターンの像が投影光学系8を介してウエハ5上に投影露光される。この際に、露光光ELのスリット状の照明領域に対して、レチクル12が図1の紙面に対して前方向に一定速度Vで走査されるのに同期して、ウエハ5は図1の紙面に対して後方向に一定速度V/M(1/Mは投影光学系8の縮小倍率)で走査される。

【0030】レチクル12及びウエハ5の駆動系について説明するに、レチクル支持台9上にY軸方向(図1の紙面に垂直な方向)に駆動自在なレチクルY駆動ステージ10が載置され、このレチクルY駆動ステージ10上

にレチクル微小駆動ステージ11が載置され、レチクル微小駆動ステージ11上にレチクル12が真空チャック等により保持されている。レチクル微小駆動ステージ11は、投影光学系8の光軸に垂直な面内で図1の紙面に平行なX方向、Y方向及び回転方向( $\theta$ 方向)にそれぞれ微小量だけ且つ高精度にレチクル12の位置制御を行う。レチクル微小駆動ステージ11上には移動鏡21が配置され、レチクル支持台9上に配置された干渉計14によって、常時レチクル微小駆動ステージ11のX方向、Y方向及び $\theta$ 方向の位置がモニターされている。干渉計14により得られた位置情報S1が主制御系22Aに供給されている。

【0031】一方、ウエハ支持台1上には、Y軸方向に駆動自在なウエハY軸駆動ステージ2が載置され、その上にX軸方向に駆動自在なウエハX軸駆動ステージ3が載置され、その上にZ $\theta$ 軸駆動ステージ4が設けられ、このZ $\theta$ 軸駆動ステージ4上にウエハ5が真空吸着によって保持されている。Z $\theta$ 軸駆動ステージ4上にも移動鏡7が固定され、外部に配置された干渉計13により、Z $\theta$ 軸駆動ステージ4のX方向、Y方向及び $\theta$ 方向の位置がモニターされ、干渉計13により得られた位置情報も主制御系22Aに供給されている。主制御系22Aは、ウエハ駆動装置22B等を介してウエハY軸駆動ステージ2、ウエハX軸駆動ステージ3、Z $\theta$ 軸駆動ステージ4の位置決め動作を制御すると共に、装置全体の動作を制御する。

【0032】また、後述するが、ウエハ側の干渉計13によって計測される座標により規定されるウエハ座標系と、レチクル側の干渉計14によって計測される座標により規定されるレチクル座標系の対応をとるために、Z $\theta$ 軸駆動ステージ4上のウエハ5の近傍に基準マーク板6が固定されている。この基準マーク板6上には後述のように各種基準マークが形成されている。これらの基準マークの中にはZ $\theta$ 軸駆動ステージ4側に導かれた照明光により裏側から照明されている基準マーク、即ち発光性の基準マークがある。

【0033】本例のレチクル12の上方には、基準マーク板6上の基準マークとレチクル12上のマークとを同時に観察するためのレチクルアライメント顕微鏡19及び20が装備されている。この場合、レチクル12からの検出光をそれぞれレチクルアライメント顕微鏡19及び20に導くための偏向ミラー15及び16が移動自在に配置され、露光シーケンスが開始されると、主制御系22Aからの指令のもとで、ミラー駆動装置17及び18によりそれぞれ偏向ミラー15及び16は退避される。更に、投影光学系8のY方向の側面部に、ウエハ5上のアライメントマーク(ウエハマーク)を観察するためのオフ・アクシス方式のアライメント装置34が配置されている。

【0034】また、主制御系22Aには、オペレータか

らのコマンドを入力するためのキーボード 22C が接続されている。本実施例の投影露光装置には、高精度に計測を行うモードの他に、後述のように簡易的にベースライン量等の計測を行うためのクイックモードがあり、オペレータはキーボード 22C を介して主制御系 22A に、これから実行するモードが、高精度モードかクイックモードかを指示する。

【0035】次に、本例の投影露光装置において、ウエハ 5 及びレチクル 12 をロードしてからアライメントを終了するまでのシーケンスにつき図 2 のフローチャートを参照して説明する。先ず図 2 のステップ 101 において、レチクルローダー（後述）上に外形基準でレチクル 12 のプリアライメントを行う。図 3 は、図 1 のレチクル微小駆動ステージ 11 上にレチクル 12 を搬送する為のレチクルローダ系を示し、この図 3 のレチクルローダーは、2 個のレチクルアーム 23A 及び 23B と、これらレチクルアーム 23A、23B に連結されたアーム回転軸 25 と、このアーム回転軸 25 を回転させる回転機構 26 とより構成されている。レチクルアーム 23A 及び 23B のレチクル載置面にはそれぞれ真空吸着用の溝 24A 及び 24B が形成されており、レチクルアーム 23A 及び 23B はアーム回転軸 25 を介してそれぞれ独立に回転できるように支持されている。

【0036】レチクル 12 のロード時には、位置 A3 で他のレチクル搬送機構（不図示）よりレチクル 12 がレチクルアーム 23A 上に受け渡される。この際に他方のレチクルアーム 23B は、例えば前工程で使用されたレチクルの搬出に使用されている。次に位置 A3 の近傍に設置されたレチクル外形プリアライメント機構（不図示）によって、レチクルアーム 23A 上でレチクル 12 が外形基準で一定の精度にアライメントされた後、レチクル 12 はレチクルアーム 23A 上に真空吸着される。次に、図 2 のステップ 102 において、回転機構 26 がアーム回転軸 25 を介してレチクルアーム 23A を回転させて、Y 方向（図 1 のレチクル駆動ステージ 10 の待機位置（受け渡し位置））の位置 B3 までレチクル 12 を移動する。

【0037】このとき、真空吸着用の溝 24A は、レチクル微小駆動ステージ 11 上の吸着位置と直交した方向で、且つレチクル 12 のパターン領域外の位置にあるので、レチクル微小駆動ステージ 11 が走査方向である y 方向の最先端に移動した状態で、レチクルアーム 23A はレチクル微小駆動ステージ 11 上にレチクル 12 を自由に出し入れできるようになっている。レチクル微小駆動ステージ 11（図 1 参照）上にレチクル 12 が達すると、アーム回転軸 25 は -Z 方向に下がり、レチクル微小駆動ステージ 11 上の真空吸着面にレチクル 12 が載置され、レチクル 12 の受け渡し完了後にレチクルアーム 23A が退避する。その後、レチクル微小駆動ステージ 11 が位置 C3 の方向にレチクル 12 を搬送して行

く。この際に、レチクルアーム 23A と 23B とは独立に駆動され、例えばそれぞれがレチクルロードとレチクルアンロードとを同時に行うことで、レチクル交換速度が向上している。

【0038】次に図 2 のステップ 103 以下でレチクル 12 のアライメントを行うが、そのための機構及び動作につき説明する。図 4 (a) はレチクル 12 上のアライメントマーク（レチクルマーク）の配置を示し、図 4

(b) はレチクル上で投影光学系の有効露光フィールドと共役な領域 33R 内での、スリット状の照明領域 32 等を示す。走査方向を y 方向として、y 方向に垂直な方向を x 方向とする。図 4 (a) において、レチクル 12 上の中央部のパターン領域の周囲には遮光部 31 が形成され、この遮光部 31 の外側に形成されているレチクルマークは、ラフサーチ用アライメントマーク 27 及び 28 と、ファインアライメントマーク 29A~29D 及び 30A~30D とに分けられる。右辺側のラフサーチ用アライメントマーク 27 は、走査方向である y 方向に沿って長い直線状パターンと、この直線状パターンの両端部に形成された十字パターンとより形成され、左辺側のラフサーチ用アライメントマーク 28 は、右辺側のラフサーチ用アライメントマーク 27 と対称的に構成されている。

【0039】また、右辺側の遮光部 31 とラフサーチ用アライメントマーク 27 の一方の十字パターンとの間に、y 方向に近接してファインアライメントマーク 29A、29B が形成され、右辺側の遮光部 31 とラフサーチ用アライメントマーク 27 の他方の十字パターンとの間に、y 方向に近接してファインアライメントマーク 29C、29D が形成されている。これらファインアライメントマーク 29A~29D と対称的に左辺側にファインアライメントマーク 30A~30D が形成されており、これらファインアライメントマーク 29A~29D 及び 30A~30D は、図 4 (a) では単に十字状マークとして示してあるが実際にはそれぞれ図 4 (c) に示すように、3 本の直線状パターンを x 方向に所定間隔で 2 組配列すると共に、3 本の直線状パターンを y 方向に所定間隔で 2 組配列したものである。

【0040】先ず図 2 のステップ 103 において、図 4 (a) の左辺側のラフサーチ用アライメントマーク 28 を図 1 のレチクルアライメント顕微鏡（以下、「RA 顕微鏡」という）20 で検出する。図 4 (b) は、この場合の RA 顕微鏡 19 及び 20 のレチクル 12 上での観察領域 19R 及び 20R を示し、ラフサーチを行う際には、ラフサーチ用アライメントマーク 27 及び 28 は、それぞれ観察領域 19R 及び 20R よりも外側であり、且つ有効露光フィールドと共役な領域 33R よりも外側にある。これは、ラフサーチの為にラフサーチ用アライメントマーク 27、28 は大きくしておく必要があるが、それに合わせて投影光学系の露光フィールドを大き



くすると、投影レンズ径を大きくする必要がありコストアップになる為である。そこで本例でラフサーチを行う際の手順につき図5を参照して説明する。

【0041】図5(a)は、ラフサーチ用アライメントマーク28の一方の十字パターン近傍の拡大図、図5

(b)は図5(a)を縮小した図であり、この図5

(a)及び(b)において、RA顕微鏡20の正方形の有効視野 $20R_{ef}$ の幅をWとして、レチクル12の外形に対するパターンの描画誤差と設置誤差との和の設計値を $\Delta R$ とする。従って、図5(b)に示すように、幅 $\Delta R$ の正方形の領域内にラフサーチ用アライメントマーク28の一方の十字パターン28aが必ず含まれている。検出対象はその十字パターン28aのx座標及びy座標であるが、本例ではそのアライメントマーク28の2軸に対して $45^\circ$ で交差する方向に、即ちx軸及びy軸に斜めにその幅Wの有効視野 $20R_{ef}$ を走査する。そして、その斜め走査の際にアライメントマーク28を横切ったときのx座標及びy座標として、その十字パターン28aのx座標及びy座標を求める。

【0042】そのためには、正の実数aの整数部をINT(a)で表すものとして、その幅 $\Delta R$ の正方形の領域をその幅Wの有効視野 $20R_{ef}$ で走査する最低の回数であるサーチ画面数は、 $\{INT(\Delta R/W) + 1\}$ となる。このサーチ画面数は予め求めておく。そして、最初の有効視野B5を中心としたその幅 $\Delta R$ の正方形の領域に、斜めにそれぞれ幅Wの $\{INT(\Delta R/W) + 1\}$ 個の有効視野A5、B5、C5、……を設定し、図1のレチクル微小駆動ステージ11を駆動して、各有効視野をステップングして順次図5(a)の有効視野 $20R_{ef}$ 内に設定しながら、各有効視野内の画像をサンプリングする。

【0043】図5(b)に示すように、少なくとも幅 $\Delta R \times \Delta R$ のサーチ範囲中にサーチ対象のアライメントマーク28の十字パターン28aは存在し、サーチ範囲に対して十分にアライメントマーク28が大きい。従って、このアライメントマーク28に対して斜め方向に有効視野をステップ送りすれば、最小の画面数で、アライメントマーク28の十字パターン28aの座標を検出できることが分かる。そのときの画像処理は、撮像された画面内の全ラインの走査線を加算して得られる画像信号に対する一次元画像処理でよい。

【0044】図6は、そのように全ラインの走査線を加算して得られた種々の画像信号を示し、図6(a)及び(d)は図5(b)の有効視野A5で得られるx方向及びy方向に沿う画像信号、図6(b)及び(e)は図5(b)の有効視野B5で得られるx方向及びy方向に沿う画像信号、図6(c)及び(f)は図5(b)の有効視野C5で得られるx方向及びy方向に沿う画像信号である。図6(b)の画像信号から十字パターン28aのx座標が求められ、図6(f)の画像信号から十字パタ

ーン28aのy座標が求められる。

【0045】この様にしてサーチ用レチクルマーク28を検出した後に、今度は図2のステップ104において、RA顕微鏡19の観察領域にラフサーチ用アライメントマーク27を移動して、同様にそのアライメントマーク27の位置を検出する。但し、この場合、図1の基準マーク板6のパターンの無い部分を投影光学系8の露光フィールド内に移動して、そのパターンの無い部分を底部から照明しておく。このように基準マーク板6から射出される照明光により、それらラフサーチ用アライメントマーク27及び28を裏面側から照明する。

【0046】以上のシーケンスで、図4(b)のRA顕微鏡19及び20の観察領域19R及び20Rに対する、ラフサーチ用アライメントマーク27及び28の位置及びレチクル座標系の対応を大まかに付けることができる。また、RA顕微鏡の観察領域19R及び20Rとウエハ座標系との大まかな対応付けは、図1の基準マーク板6上の基準マークをRA顕微鏡19及び20で計測することにより行うことができる。これにより、ファインアライメントマーク29A~29D及び30A~30Dと、基準マーク板6上の基準マーク(後述)とが重ならない程度の、大まかなアライメント(ラフアライメント)が終了する。

【0047】但し、本例では、投影光学系8のレンズ径を小さくするために、レチクル12上のアライメントマークをラフサーチ用アライメントマークとファインアライメントマークとに分けているが、投影光学系8のレンズ径を大きくしても良い場合は、それらラフサーチ用アライメントマークとファインアライメントマークとを共通マークにすることができる。この場合でも、図5に示したように、斜め方向にステップ送りしてアライメントマークをサーチする手法は流用でき、RA顕微鏡19及び20でアライメントマークのサーチを同時に行うこともできる。

【0048】次に、ファインアライメントのシーケンスについて説明するが、その前にウエハステージ及びレチクルステージの詳細な構成につき説明する。図7(a)はウエハステージの平面図であり、この図7(a)において、Z軸駆動ステージ4の上にウエハ5及び基準マーク板6が配置されている。また、Z軸駆動ステージ4上には、X軸用移動鏡7X及びY軸用移動鏡7Yが固定され、ウエハ5上で図4(b)のスリット状の照明領域32に対応するスリット状の照明領域32Wが露光光で照明され、観察領域19W及び20Wがそれぞれ図4(b)の観察領域19R及び20Rと共役である。

【0049】移動鏡7Xには、X軸に平行で且つそれぞれ投影光学系の光軸及びアライメント装置34の基準点を通る光路に沿って間隔ILのレーザービームLWX及びLWorが照射され、移動鏡7Yには、Y軸に平行な光路に沿って間隔ILの2本のレーザービームLWY1及

びLWY2が照射されている。露光時には、Zθ軸駆動ステージ4のX座標として、レーザービームLWXを用いる干渉計で計測された座標値が使用され、Y座標としてレーザービームLWY1及びLWY2をそれぞれ用いる干渉計で計測された座標値Y<sub>1</sub>及びY<sub>2</sub>の平均値 $(Y_1 + Y_2) / 2$ が用いられる。また、例えば座標値Y<sub>1</sub>とY<sub>2</sub>との差分からZθ軸駆動ステージ4の回転方向(θ方向)の回転量が計測される。それらの座標に基づいて、Zθ軸駆動ステージ4のXY平面の位置及び回転角が制御される。

【0050】特に、走査方向であるY方向は2個の干渉計の計測結果の平均値を用いる事で、走査時の空気揺らぎ等による誤差を平均化効果により緩和している。また、オフ・アクシス方式のアライメント装置34を使用する場合のX軸方向の位置は、所謂アップ誤差が生じない様に、レーザービームLWorを使用する専用干渉計の計測値に基づいて制御される構成である。

【0051】図7(b)は、レチクルステージの平面図であり、この図7(b)において、レチクルY駆動ステージ10上にレチクル微小駆動ステージ11が載置され、その上にレチクル12が保持されている。また、レチクル微小駆動ステージ11にはx軸用の移動鏡21x及びy軸用の2個の移動鏡21y1、21y2が固定され、移動鏡21xにはx軸に平行にレーザービームLRxが照射され、移動鏡21y1、21y2にはそれぞれy軸に平行にレーザービームLRy1、LRy2が照射されている。

【0052】ウエハステージと同様に、レチクル微小駆動ステージ11のy方向の座標は、レーザービームLRy1及びLRy2を使用する2個の干渉計で計測された座標値y<sub>1</sub>及びy<sub>2</sub>の平均値 $(y_1 + y_2) / 2$ が用いられる。また、x方向の座標は、レーザービームLRxを使用する干渉計で計測された座標値が使用される。また、例えば座標値y<sub>1</sub>とy<sub>2</sub>との差分からレチクル微小駆動ステージ11の回転方向(θ方向)の回転量が計測される。

【0053】この場合、走査方向であるy方向の移動鏡21y1、21y2としてはコーナキューブ型の反射要素が使用されており、移動鏡21y1、21y2で反射されたレーザービームLRy1、LRy2はそれぞれ反射ミラー39、38で反射されて戻されている。即ち、そのレチクル用の干渉計はダブルパス干渉計であり、これによって、レチクル微小駆動ステージ11の回転によりレーザービームの位置ずれが生じない構成になっている。また、ウエハステージ上と同様に、レチクル12上にスリット状の照明領域32及びRA顕微鏡19、20の観察領域19R、20Rが配置されている。そして、観察領域19R及び20Rだけから、レチクル12と図7(a)のZθ軸駆動ステージ4を観察できる様になっている。この様にレチクル12とZθ軸駆動ステージ4

との関係を計測して露光時のアライメント精度及びレチクル12とウエハ5との回転精度を向上させる訳であるが、その方法につき図8及び図9を参照して説明する。

【0054】図8(a)は、図4(a)のレチクル12を図7(a)の基準マーク板6上に投影して得られるレチクル像12Wを示し、この図8(a)において、図4(a)のファインアライメントマーク29A~29Dに共役なマーク像29AW~29DWと、ファインアライメントマーク30A~30Dに共役なマーク像30AW~30DWとが示されている。各マーク像29AW~29DW及び30AW~30DWは、それぞれ図8(b)に示すように、3本の直線状のパターンを4辺に配置した形状である。

【0055】図8(c)は、基準マーク板6上の基準マークの配置を示し、この図8(c)の基準マーク板6上には、図8(a)のマーク像29AW~29DW及び30AW~30DWとほぼ同一の配置でそれぞれ基準マーク35A~35D及び36A~36Dが形成されている。これら基準マークは基準マーク板6の裏面から、露光光と同じ波長の照明光で照明されている。また、基準マーク板6上には、基準マーク35A及び36Aの中点から走査方向であるY方向に間隔ILだけ離れた位置に基準マーク37Aが形成されている。間隔ILは、図1における投影光学系8の基準点とオフ・アクシス方式のアライメント装置34の基準点との間隔であるベースライン量と等しい。同様に、基準マーク35B及び36Bの中点、基準マーク35C及び36Cの中点及び基準マーク35D及び36Dの中点からそれぞれY方向に間隔ILだけ離れた位置に、基準マーク37B、37C及び37Dが形成されている。

【0056】基準マーク35A~35D、36A~36Dはそれぞれ図8(d)に示すように、7行×7列の直線状パターンから構成され、且つこれら基準マーク35A~35D、36A~36Dは図8(b)のマーク像29AW~30DWの内部に収まる大きさである。また、基準マーク37A~37Dは、図8(e)に示すように、X方向及びY方向に所定ピッチで形成された格子パターンの内の対応する格子点を使用するものである。

【0057】この場合、先ず図2のステップ105において、ステップ103及び104の計測により得られた結果から、レチクル12とRA顕微鏡19及び20との相対的な位置関係及び相対的な回転角を算出し、図4(a)のファインアライメントマーク29A及び30AをそれぞれRA顕微鏡19及び20の観察領域19R及び20R内に移動させる。その後、ステップ106において、図8(c)の基準マーク板6上の基準マーク35A及び36Aをそれぞれその観察領域19R及び20Rと共役な観察領域19W及び20W(図9参照)に移動する。これにより、図9(a)に示すように、観察領域19W内でマーク像29AWと基準マーク35Aとが同



時に観察でき、観察領域20W内でマーク像30AWと基準マーク36Aとが同時に観察できる。その後、図2のステップ107において、RA顕微鏡19及び20で観察される画像を撮像信号に変換してサンプリングすると同時に、オフ・アクシス方式のアライメント装置34でも対応する基準マーク像の検出信号をサンプリングする。

【0058】図9(a)においては、基準マーク板6上にレチクル12の投影像であるレチクル像12Wが投影されている。また、図9(c)に示すように、観察領域19W及び20Wは、それぞれ投影光学系8の露光フィールド内の光軸を横切る位置に有り、オフ・アクシス方式のアライメント装置34の観察領域内に基準マーク37Aが収まっている。そして、スリットスキャン露光時と同様に、図7(a)のZθ軸駆動ステージ4が上側(Y方向)に移動するのと同期して、図7(b)のレチクル微小駆動ステージ11が下側(-y方向)に移動すると、第9(a)から図9(b)に示すように、基準マーク板6とレチクル像12Wとが一緒にY方向に動く。このとき、RA顕微鏡19、20の観察領域19W、20Wとオフ・アクシス方式のアライメント装置34とは固定されているので、観察領域19W、20W及びアライメント装置34の下を、符号Aが付されたマーク群(マーク像29AW、30AW、基準マーク35A、36A、37A)から符号Dが付されたマーク群(マーク像29DW、30DW、基準マーク35D、36D、37D)までが移動して行く。

【0059】先ず、アライメント開始後の図9(a)の第1の静止位置では、観察領域19Wの下にマーク像29AW及び基準マーク35Aがあり、観察領域20Wの下にはマーク像30AW及び基準マーク36Aがあり、オフ・アクシス方式のアライメント装置34の下には基準マーク37Aがあり、これら符号Aが付されたマークは同時にすべて観察される。第1の静止位置での計測が終了すると、ステッピング動作によって第2の静止位置までレチクル像12Wと基準マーク板6とを同期して移動させる。第1の静止位置で観察領域19W、20W及びアライメント装置34の下に存在したマーク群は符号Aが付されたマーク群であり、第2の静止位置で観察領域19W、20W及びアライメント装置34の下に存在するマーク群は符号Bが付されたマーク群(図8のマーク像29BP、基準マーク35B、37B等)である。

【0060】以上の様なシーケンスを第3の静止位置及び第4の静止位置(図9(b)の状態)と繰り返すことにより、レチクル像12Wのマーク像及び基準マーク板6上の基準マークは、符号Aが付されたマーク群、符号Bが付されたマーク群、符号Cが付されたマーク群、符号Dが付されたマーク群の順に、それぞれRA顕微鏡19、20及びオフ・アクシス方式のアライメント装置34によって計測されていくことになる。この動作が、図

2のステップ105~110の動作である。この様にして求められた計測結果を分かり易く表現するために、計測結果を図10に示す。

【0061】図10において、RA顕微鏡19で得られる測定結果を後述のように補正して求められる、基準マーク35Aからマーク像29AWまでのアライメント誤差のベクトルをALとして、同様に基準マーク35B~35Dからそれぞれマーク像29BW~29DWまでのアライメント誤差のベクトルをBL~DLとする。同様に、基準マーク36Aからマーク像30AWまでのアライメント誤差のベクトルをARとして、基準マーク36B~36Dからそれぞれマーク像30BW~30DWまでのアライメント誤差のベクトルをBR~DRとする。また、オフ・アクシス方式のアライメント装置34で得られる計測結果を後述のように補正して求められる、基準マーク37A~37Dからそのアライメント装置34の基準点までの誤差ベクトルをそれぞれAO~DOとする。

【0062】そして、誤差ベクトルAL、AR~DL、DRを得たときの、図1のレチクル側の干涉計14で計測されたx方向の座標値、即ち図7(b)のレーザービームLRxを用いて得られた座標値をそれぞれReAx~ReDx、誤差ベクトルAL、AR~DL、DRを得たときの、図1のレチクル側の干涉計14で計測されたy方向の座標値、即ち図7(b)のレーザービームLRy1、LRy2を用いて得られた座標値をそれぞれReAy1~ReDy1、ReAy2~ReDy2とする。また、誤差ベクトルAL、AR~DL、DRを得たときの、図1のウエハ側の干涉計13で計測されたX方向の座標値、即ち図7(a)のレーザービームLWXを用いて得られた座標値をそれぞれWaAX~WaDX、誤差ベクトルAL、AR~DL、DRを得たときの、図1のウエハ側の干涉計13で計測されたY方向の座標値、即ち図7(a)のレーザービームLWY1、LWY2を用いて得られた座標値をそれぞれWaAY1~WaDY1、WaAY2~WaDY2とする。

【0063】また、誤差ベクトルAO~DOを得たときの、オフ・アクシス方式のアライメント装置専用の干涉計で得られたX方向の座標値、即ち図7(a)のレーザービームLWofを用いて得られた座標値をそれぞれWaAOX~WaDOXとする。この場合、図7(a)に示すように、ウエハ側のレーザービームLWY1、LWY2のX方向の間隔はILであり、レチクル側のレーザービームLRy1、LRy2のウエハ側での間隔はRLである。

【0064】次に、図10の誤差ベクトルAL等の求め方につき説明するために、図1のRA顕微鏡19の構成を詳細に説明する。図11は、RA顕微鏡19及びこの照明系を示し、この図11において、Zθ軸駆動ステージ4の外部より光ファイバー44を介して露光光と同じ

波長の照明光  $E_L$  が  $Z$  軸駆動ステージ 4 の内部に導かれている。光ファイバー 4 4 の代わりにレンズ系で露光光をリレーしても良い。そのように導かれた照明光が、レンズ 4 5 A、ビームスプリッター 4 5 B 及びレンズ 4 5 C を経て基準マーク板 6 上の基準マーク 3 5 A ~ 3 5 D を照明し、ビームスプリッター 4 5 B を透過した照明光が、レンズ 4 5 D、レンズ 4 5 E、ミラー 4 5 F 及びレンズ 4 5 G を経て基準マーク板 6 上の基準マーク 3 6 A ~ 3 6 D を照明している。

【0065】例えば基準マーク 3 5 A を透過した光は、投影光学系 8 を介して、レチクル 1 2 上のファインアライメントマーク 2 9 上にその基準マーク 3 5 A の像を結像する。その基準マーク 3 5 A の像及びアライメントマーク 2 9 からの光が、偏向ミラー 1 5、レンズ 4 0 A、レンズ 4 0 B を経てハーフミラー 4 2 に達し、ハーフミラー 4 2 で 2 分割された光がそれぞれ 2 次元 CCD よりなる X 軸用の撮像素子 4 3 X 及び Y 軸用の撮像素子 4 3 Y の撮像面に入射する。これら撮像素子 4 3 X 及び 4 3 Y の撮像面にはそれぞれ図 1 2 (a) に示すような、ファインアライメントマーク 2 9 A 及び基準マーク 3 5 像 3 5 A R の像が投影される。この場合、X 軸用の撮像素子 4 3 X の撮像画面 4 3 X a は、ウエハステージ上の X 方向に平行な領域で、且つ水平走査線方向も X 方向であるが、Y 軸用の撮像素子 4 3 Y の撮像画面 4 3 Y a は、ウエハステージ上の Y 方向に平行な領域で、且つ水平走査線方向も Y 方向である。

【0066】従って、撮像素子 4 3 X の撮像信号  $S_{4X}$  の加算平均から基準マーク 3 5 A とアライメントマーク 2 9 A との X 方向の位置ずれ量が求められ、撮像素子 4 3 Y の撮像信号  $S_{4Y}$  の加算平均から基準マーク 3 5 A とアライメントマーク 2 9 A との Y 方向の位置ずれ量が求められる。これら撮像信号  $S_{4X}$  及び  $S_{4Y}$  が信号処理装置 4 1 に供給されている。

【0067】より詳細に、符号 A が付されたマーク群をアライメントしている場合を例に取って説明すると、R A 顕微鏡 1 9 では例えば図 1 2 (a) に示されているアライメントマーク 2 9 A と基準マーク像 3 5 A R とを同時に観察する。この図 1 2 (a) において、破線で囲まれた撮像画面 4 3 X a 及び 4 3 Y a 内の画像信号  $S_{4X}$  及び  $S_{4Y}$  が、信号処理装置 4 1 内でアナログ/デジタル変換によりデジタル信号として検出される。それぞれの走査線上の画像データは、信号処理装置 4 1 内で、X 軸及び Y 軸で独立に加算平均され、加算平均された X 軸用の画像信号  $S_{4X'}$  及び Y 軸用の画像信号  $S_{4Y'}$  はそれぞれ図 1 2 (b) 及び (c) に示されるようになる。これら画像データはそれぞれ 1 次元画像処理信号として処理される。

【0068】この様にして得られた信号を信号処理装置 4 1 で演算処理すると、図 1 0 のレチクル 1 2 のマーク像 2 9 A W と基準マーク板 6 の基準マーク 3 5 A との X

方向及び Y 方向の相対的な位置ずれ  $AL'_x$  及び  $AL'_y$  が求められる。そして、図 1 の R A 顕微鏡 2 0 により、マーク像 3 0 A W と基準マーク 3 6 A との X 方向及び Y 方向の相対的な位置ずれ  $AR'_x$  及び  $AR'_y$  が求められる。同様に、図 1 0 のマーク像 2 9 B W ~ 2 9 D W と基準マーク 3 5 B ~ 3 5 D との相対的な位置ずれ、及びマーク像 3 0 B W ~ 3 0 D W と基準マーク 3 6 B ~ 3 6 D との相対的な位置ずれが求められる。

【0069】しかし、例えば図 1 2 (b) のアライメントマーク 2 9 A に対応する画像信号と、基準マーク像 3 5 A R に対応する画像信号とは、それぞれレチクル側の干渉計とウエハ側の干渉計とによって位置を制御されている。従って、例えば符号 A が付されたマーク群 (図 1 0 の 2 9 A W, 3 5 A, 3 0 A W, 3 6 A) を計測している際のレチクル側の干渉計の計測座標  $ReAx$ ,  $ReAy_1$ ,  $ReAy_2$  と、ウエハ側の干渉計の計測座標  $WaAX$ ,  $WaAY_1$ ,  $WaAY_2$  とに対して、各ステージの追従誤差に起因する計測誤差 (= 実測値 - 設定値) である  $\Delta ReAx$ ,  $\Delta ReAy_1$ ,  $\Delta ReAy_2$  と、 $\Delta WaAX$ ,  $\Delta WaAY_1$ ,  $\Delta WaAY_2$  とが生ずる。この計測誤差が先ほど演算により求められた相対的な位置ずれ  $AL'_x$ ,  $AL'_y$  に含まれている。

【0070】そこで次式のように、計測により得られた相対的な位置ずれからそれらの誤差を差し引いた結果が、図 1 0 のアライメント誤差のベクトル  $AL$  の X 成分  $AL_x$  及び Y 成分  $AL_y$  となる。但し、次式において  $(1/M)$  は投影光学系 8 の縮小倍率であり、 $IL$  及び  $RL$  はそれぞれ図 7 で説明した間隔である。

【0071】

【数 1】  $AL_x = AL'_x - \Delta ReAx / M - \Delta WaAX$   
【0072】

【数 2】  $AL_y = AL'_y - \Delta ReAy_1 / M - \{ (\Delta WaAY_1 + \Delta WaAY_2) / 2 - (\Delta WaAY_2 - \Delta WaAY_1) \cdot RL / IL \}$

【0073】同様に、図 1 0 のアライメント誤差のベクトル  $AR$  の X 成分  $AR_x$  及び Y 成分  $AR_y$  も次式から求められる。

【0074】

【数 3】  $AR_x = AR'_x - \Delta ReAx / M - \Delta WaAX$   
【0075】

【数 4】  $AR_y = AR'_y - \Delta ReAy_2 / M - \{ (\Delta WaAY_1 + \Delta WaAY_2) / 2 - (\Delta WaAY_2 - \Delta WaAY_1) \cdot RL / IL \}$

【0076】次に、オフ・アクシス方式のアライメント装置 3 4 により得られる結果を補正して得られる図 1 0 の誤差ベクトル  $AO \sim DO$  について説明するが、そのためにそのアライメント装置 3 4 の構成につき図 1 3 を参照して説明する。

【0077】図 1 3 は、そのアライメント装置 3 4 の構成を示し、この図 1 3 において、基準マーク板 6 上の基

準マークからの光は、偏向ミラー部 46 で偏向されてハーフプリズム 47 に入射し、ハーフプリズム 47 で反射された光が白色光を用いた画像処理方式のアライメント光学系（以下「FIA 光学系」という）48 に向かい、ハーフミラーを透過した光が、ヘテロダインビームにより格子マークからの回折光を検出するためのアライメント光学系（以下「LIA 光学系」という）52 に入射する。

【0078】先ず、FIA 光学系 48 側から説明すると、照明光源 49 からの照明光は FIA 光学系 48 を経た後、ハーフプリズム 47 及び偏向ミラー 46 によって偏向されて、基準マーク板 6 上の基準マークを照明する。その戻り光は同じ光路を辿って FIA 光学系 48 に戻り、FIA 光学系 48 を通過した光がハーフプリズム 50A に入射し、ハーフプリズム 50A を透過した光束が 2 次元 CCD よりなる X 軸用の撮像素子 51X の撮像面上に基準マーク板 6 上の基準マーク像を結像し、ハーフプリズム 50A で反射された光束が 2 次元 CCD よりなる Y 軸用の撮像素子 51Y の撮像面上に基準マーク板 6 上の基準マーク像を結像する。

【0079】それぞれの撮像素子 51X 及び 51Y の撮像面上には、図 14 (a) に示すような画像が結像される。基準マーク板 6 上の基準マークは格子状のパターンの格子点であり、図 14 (a) にはその格子状のパターンの像 37P が投影されている。その格子状のパターンの像 37P の基準マーク板 6 上での格子ピッチを P、暗線の幅を L とすると、幅 L は格子ピッチ P よりかなり小さく設定されている。また、その撮像面上には、基準マーク板 6 の照明光とは別の照明光で照明された X 方向用の参照マーク（指標マーク）像 48X1、48X2 及び Y 方向用の指標マーク像 48Y1、48Y2 が結像されている。それら指標マーク像の位置を基準として、基準マーク板 6 上の基準マークの位置を検出することができ

る。

【0080】具体的には、図 14 (a) の中で X 方向と共役な方向の撮像領域 51Xa 及び Y 方向と共役な方向の撮像領域 51Ya が、それぞれ図 13 の撮像素子 51X 及び 51Y で撮像される。撮像素子 51X 及び 51Y の水平走査線の方法はそれぞれ X 方向及び Y 方向と共役な方向であり、撮像素子 51X 及び 51Y のそれぞれの撮像信号 S5X 及び S5Y が図 13 の信号処理装置 56 に供給される。信号処理装置 56 では、撮像信号 S5X 及び S5Y をそれぞれ加算平均して、図 14 (b) の画像信号 S5X' 及び図 14 (c) の画像信号 S5Y' を得、これら画像信号から基準マーク板 6 上の対象とする基準マークの位置ずれを求める。さらに詳細な構成は、特願平 4-16589 号に開示されている。

【0081】検出対象とする基準マークが図 10 の基準マーク 37A の場合に、図 14 (a) の画像処理により得られる、基準マーク 37A の参照マークに対する X 方

向及び Y 方向の相対的な位置ずれをそれぞれ  $AO'_x$  及び  $AO'_y$  とする。このときの基準マーク板 6 の位置はウエハ座標系で管理されているので、その計測結果から図 7 (a) の Z 軸駆動ステージ 4 の追従誤差及び回転誤差を引いた値が、図 10 の誤差ベクトル AO の X 成分  $AO_x$  及び Y 成分  $AO_y$  となる。但し、図 13 の FIA 光学系 48 に対応する X 成分  $AO_x$  及び Y 成分  $AO_y$  をそれぞれ  $AO_{\alpha}$  及び  $AO_{\beta}$  とする。即ち、次式が得られる。

【0082】

【数 5】  $AO_{\alpha} = AO'_x - (Wa AO_X - Wa AX)$

【0083】

【数 6】

$AO_{\beta} = AO'_y - (Wa AY_1 + Wa AY_2) / 2$

【0084】一方、図 13 の LIA 光学系 52 を含むアライメント系では、レーザ光源 53 からのレーザ光が、LIA 光学系 52、ハーフプリズム 47 を透過した後、偏向ミラー 45 で偏向されて基準マーク板 6 上の回折格子状の基準マークに入射する。その基準マークからの回折光は、同じ光路を辿って LIA 光学系 52 に戻り、LIA 光学系 52 を通過した回折光は、ハーフプリズム 50B で 2 分割されて X 方向用の受光素子 55X 及び Y 方向用の受光素子 55Y に入射する。

【0085】この際に、LIA 光学系 52 内でレーザ光源 53 からのレーザ光は 2 分割され、内部の周波数シフターによってそれら 2 つのレーザ光の周波数には  $\Delta f$  の周波数差が与えられている。それら 2 つのレーザ光の干渉光が受光素子 54 で受光され、その受光素子からは周波数  $\Delta f$  の参照信号 S6 が出力される。また、それら 2 つの周波数の異なるレーザ光（ヘテロダインビーム）がある適当な入射角で基準マーク板 6 上の回折格子状の基準マークに照射され、その基準マークによるそれら 2 本のレーザ光の  $\pm 1$  次回折光が、平行に基準マーク板 6 に対して垂直に戻るようになっている。、その  $\pm 1$  次光の干渉光は周波数  $\Delta f$  で光強度が変化するが、位相が基準マークの X 座標及び Y 座標に応じて変化する。そして、受光素子 55X からは、基準マークの X 座標に応じて位相が変化している周波数  $\Delta f$  のビート信号 S7X が出力され、受光素子 55Y からは、基準マークの Y 座標に応じて位相が変化している周波数  $\Delta f$  のビート信号 S7Y が出力され、参照信号 S6 及びビート信号 S7X、S7Y は信号処理装置 56 に供給されている。

【0086】検出対象の基準マークを図 10 の基準マーク 37A とすると、図 13 の信号処理装置 56 は、図 14 (d) に示すように、参照信号 S6 とビート信号 S7X との位相差  $\Delta \phi_x$  より、基準マーク 37A の X 方向の位置ずれ  $AO'_x$  を求め、図 14 (e) に示すように、参照信号 S6 とビート信号 S7X との位相差  $\Delta \phi_y$  より、基準マーク 37A の Y 方向の位置ずれ  $AO'_y$  を求める。この計測結果から図 7 (a) の Z 軸駆動ステー

ジ4の追従誤差及び回転誤差を引いた値が、図10の誤差ベクトルAOのX成分AO<sub>x</sub>及びY成分AO<sub>y</sub>となる。但し、図13のLIA光学系52に対応するX成分AO<sub>x</sub>及びY成分AO<sub>y</sub>をそれぞれAO<sub>Lx</sub>及びAO<sub>Ly</sub>とする。即ち、次式が得られる。

【0087】

【数7】  $AO_{Lx} = AO'_{Lx} - (WaAOX - WaAX)$

【0088】

【数8】

$AO_{Ly} = AO'_{Ly} - (WaAY1 + WaAY2) / 2$  10

【0089】以上の様にして、図10の符号Aが付されたマーク群の位置でアライメントを行うと、AL<sub>x</sub>、AL<sub>y</sub>、AR<sub>x</sub>、AR<sub>y</sub>、AO<sub>α</sub>、AO<sub>α'</sub>、AO<sub>Lx</sub>、AO<sub>Ly</sub>の8個のデータが計測される。この様なシーケンスで符号Aが付されたマーク群～符号Dが付されたマーク群までの計測を行うことによって、32個(=8×4)のデータが求められる。これら32個のデータの中で、RA顕微鏡19及び20により得られたデータを実測データD<sub>xn</sub>、D<sub>yn</sub>として記憶し、オフ・アクシス方式のアライメント装置34により得られたデータを実測データA<sub>xn</sub>、A<sub>yn</sub>として記憶する。その後、動作は図2のステップ111に移行する。

【0090】図2のステップ111において、RA顕微鏡19、20に対応する実測データD<sub>xn</sub>、D<sub>yn</sub>に対して、実際にレチクル座標系とウエハ座標系とを線形誤差のみで変換できるようにした座標系での、x方向及びy方向の座標をF<sub>xn</sub>及びF<sub>yn</sub>とすると、これらの関係は以下の様になる。

【0091】

【数9】

$$\begin{bmatrix} F_{xn} \\ F_{yn} \end{bmatrix} = \begin{bmatrix} R_x & -R_x \cdot (\omega + \theta) \\ R_y \cdot \theta & R_y \end{bmatrix} \begin{bmatrix} D_{xn} \\ D_{yn} \end{bmatrix} + \begin{bmatrix} O_x \\ O_y \end{bmatrix}$$

【0092】また、x方向及びy方向の非線形誤差をε<sub>xn</sub>及びε<sub>yn</sub>とすると、次式が成立する。

【0093】

【数10】

$$\begin{bmatrix} \varepsilon_{xn} \\ \varepsilon_{yn} \end{bmatrix} = \begin{bmatrix} F_{xn} \\ F_{yn} \end{bmatrix} - \begin{bmatrix} D_{xn} \\ D_{yn} \end{bmatrix}$$

$$= \begin{bmatrix} 1 - R_x & -R_x \cdot (\omega + \theta) \\ R_y \cdot \theta & 1 - R_y \end{bmatrix} \begin{bmatrix} D_{xn} \\ D_{yn} \end{bmatrix} + \begin{bmatrix} O_x \\ O_y \end{bmatrix}$$

【0094】そして、これら非線形誤差(ε<sub>xn</sub>、ε<sub>yn</sub>)が最小となる様に最小自乗近似を用いて、(数9)の6つのパラメータR<sub>x</sub>、R<sub>y</sub>、θ、ω、O<sub>x</sub>、O<sub>y</sub>の値を算出する。ここでx方向のスケーリングパラメータR<sub>x</sub>はレチクル12と基準マーク板6とのx方向の倍率誤差を示し、スケーリングパラメータR<sub>y</sub>はレチクル座標系とウエハ座標系との走査方向(y方向)のスケーリング

誤差を示す。また、角度パラメータθはレチクル12と基準マーク板6と回転誤差、角度パラメータωはレチクル座標系とウエハ座標系との走査方向の平行度、オフセットパラメータO<sub>x</sub>及びO<sub>y</sub>は両者のx方向及びy方向のオフセット値をそれぞれ示す。

【0095】次に、図2のステップ112及び113において、ベースライン量を求める。この場合、オフ・アクシス方式のアライメント装置34で計測されたデータA<sub>xn</sub>及びA<sub>yn</sub>の平均値をそれぞれ<A<sub>x</sub>>及び<A<sub>y</sub>>として、ベースライン量計測時のオフセットは(<A<sub>x</sub>>-O<sub>x</sub>、<A<sub>y</sub>>-O<sub>y</sub>)となる。従って、アライメント時には、図7(a)のレーザービームLWXを用いる干渉計(以下、「露光用干渉計LWX」とも呼ぶ)からレーザービームLWofを用いる干渉計(以下、「オフ・アクシス専用干渉計LWof」とも呼ぶ)に制御を切り換え、図13のFIA光学系48を使用する場合には、計測されたデータA<sub>xn</sub>及びA<sub>yn</sub>の平均値をそれぞれ<A<sub>f</sub><sub>x</sub>>及び<A<sub>f</sub><sub>y</sub>>とする。そして、オフセット(<A<sub>f</sub><sub>x</sub>>-O<sub>x</sub>、<A<sub>f</sub><sub>y</sub>>-O<sub>y</sub>)のオフセットを図7(a)のレーザービームLWY1、LWY2、LWofに対応する干渉計の計測値に持たせてアライメント処理を行えばよい。一方、図13のLIA光学系52を使用する場合には、計測されたデータA<sub>xn</sub>及びA<sub>yn</sub>の平均値をそれぞれ<A<sub>L</sub><sub>x</sub>>及び<A<sub>L</sub><sub>y</sub>>とする。そして、干渉計の計測値に(<A<sub>L</sub><sub>x</sub>>-O<sub>x</sub>、<A<sub>L</sub><sub>y</sub>>-O<sub>y</sub>)のオフセットをもたせればよい。

【0096】なお、以上の補正方式は、ステージ座標系の基準座標系を基準マーク板6上の基準マークに基づいて設定することを意味している。この場合には、言い換えると、例えば基準マーク板6上の基準マーク37A～37Dを通る軸が基準軸となり、この基準軸上で露光用干渉計LWXの読み値を0とした場合の、この基準軸上でのオフ・アクシス専用干渉計LWofの読み値(ヨーイング値)が求められる。そして、露光時には、露光用干渉計LWXの読み値と、オフ・アクシス専用干渉計LWofの実際の読み値にそのヨーイング値の補正を行った結果とを、それぞれ「受渡し用の干渉計値」として、この受渡し用の干渉計値に基づいてウエハ5の位置合わせを行うものである。

【0097】これに対して、例えば図7(a)において、ステージ座標系の基準軸をX軸用の移動鏡7Xとする方法を使用してもよい。この場合には、先ず図7

(a)の状態で、露光用干渉計LWXの読み値、及びオフ・アクシス専用干渉計LWofの読み値を同時にリセット(0に)し、以後の露光時には受渡し用の干渉計値を用いることなく計測値そのものを使用する。一方、アライメント時には、例えば基準マーク板6上の基準マーク37A～37Dを通る基準軸の移動鏡7Xに対する傾斜角θ<sub>xf</sub>を求め、レーザービームLWXとLWofとの間隔Lを用いて、オフ・アクシス専用干渉計LWofの読み値

に  $IL \cdot \theta_{xf}$  の補正を行って得た値を用いる。これにより、通常の露光時には露光用干渉計  $LWX$  の読み値、及びオフ・アクシス専用干渉計  $LW_{of}$  の読み値をそのまま使用できるようになる。

【0098】次に、計測データ  $D_m$ 、 $D_y$  は、ウエハ座標系とレチクル座標系との相対誤差のみを表しているの  
で、ウエハ座標系基準で最小自乗近似計算を行った場合は、求められたパラメータ  $R_x$ 、 $R_y$ 、 $\theta$ 、 $\omega$ 、 $O_x$ 、 $O_y$  はすべてウエハ座標系を基準としたレチクル座標系の線形誤差で表される。そこで、レチクル座標系の  $x$  座標及び  $y$  座標をそれぞれ  $r_{xm}$ 、及び  $r_{ym}$  とすると、ウエハ座標系の動きに応じて次式から求められた新座標  
( $r_{xm}$ 、 $r_{ym}$ ) に基づいてレチクルを駆動すれば良い。

【0099】

【数11】

$$\begin{bmatrix} r_{xn} \\ r_{yn} \end{bmatrix} = \begin{bmatrix} R_x & -R_x \cdot (\omega + \theta) \\ R_y \cdot \theta & R_y \end{bmatrix} \begin{bmatrix} r_{xm} \\ r_{ym} \end{bmatrix} + \begin{bmatrix} O_x \\ O_y \end{bmatrix}$$

【0100】この処理では、既にオフセット  $O_x$ 、 $O_y$  の補正がレチクル側でなされているので、ベースライン量としては ( $\langle Ax \rangle$ 、 $\langle Ay \rangle$ ) のオフセットを補正するのみでよい。また、レチクル座標系を基準とした場合は、すべて逆の結果となり、ウエハ座標系で補正することも可能である。またこれらの補正はラフアライメント時はウエハ座標系で補正し、ファインアライメント時はレチクル座標系で行う等の様に分けて制御してもかまわない。

【0101】以上の様に本実施例によれば、1回のレチクルアライメント時に、複数のマークを利用してレチクルアライメント及びベースライン量のチェックを行うので、レチクルの描写誤差と、レチクル及びウエハの位置合わせ誤差とを平均化する事が可能となり、アライメン

ト精度が向上する。更に、これらの工程をすべて同時に行うのでスループットも向上する。更に、非走査方向（ $X$ 方向）において複数の基準マークを同時に計測できる基準マーク板6を採用している為に、干渉計の光路の空気揺らぎによる誤差が生じない。

【0102】しかしながら、走査方向には基準マーク板6がステップ的に移動するので空気揺らぎによる影響が考えられる。その為ベースライン量のチェック時に、図13のLIA光学系52を用いた処理を行う際に、受光素子55X及び55Yの出力値を用いてウエハステージ（ $Z$ 軸駆動ステージ4等）の位置をロックして、レチクルアライメント及びベースライン量のチェックを行えば、空気揺らぎの影響は最小限に抑えられる。また、本例のレチクルマークはレチクル12の4隅の計8箇所に配置されている。これはレチクル座標系とウエハ座標系との対応関係を調べる為に、オフセットのみでなく、パラメータ  $R_x$ 、 $R_y$ 、 $\theta$ 、 $\omega$  が必要であり、4隅にマークを配置した方がパラメータ  $R_y$ 、 $\theta$ 、 $\omega$  の決定には有利である事による。更に、発光性の基準マーク板6を用いる場合は、発光部に制限があり、基準マーク板6上の全面を発光させることが難しい為である。

【0103】また、レチクル12上のレチクルマーク数を  $n$  とすると、オフセットパラメータ  $O_x$ 、 $O_y$  は  $1/n^{1/2}$  に平均化され、他のパラメータの誤差も小さくなる。従って、レチクルマーク数  $n$  を増加する程誤差は小さくなる。以下に、レチクルマーク数  $n$  とパラメータの誤差及びベースライン量の誤差との関係をシミュレーションした結果を示す。以下では（数11）の新座標系での4隅でのばらつきを、標準偏差  $\sigma$  の3倍で且つ単位

【nm】で表す。

【0104】

【表1】

レチクル マーク数 $n$	$R_x, R_y, \theta, \omega$ の誤差		ベースライン量 の誤差		
座標軸	X	Y	X	Y	悪い方の自乗和
4	9.59	10.96	8.8	7.2	16.00
8	7.10	7.92	6.2	5.1	9.43
12	5.86	6.48	5.1	4.2	7.77
16	5.03	5.80	4.4	3.6	6.83

【0105】以上よりレチクルマーク数  $n$  を8個とすることにより、レチクル描画誤差を50nm、ステージのステッピング誤差を10nmとしても、レチクルアライメント及びベースライン量のチェックの精度を10nm以下にできることが分かる。即ち、発光性の基準マーク板6の制限以内で処理速度を早くして、レチクルマーク数  $n$  を多くとっていけば、より精度を向上させる事も可

能となる。

【0106】この際に基準マーク板6上のパターンニング誤差及び投影光学系8のディストーション誤差が新座標系の中に誤差として残るが、これらは変動がほとんどないので、装置調整時に露光結果を参照データと比較して、得られた誤差をシステムオフセットとして取り除けば問題はない。なお、上述実施例では、図8(c)に示

すように、基準マーク板6上に基準マーク35A～35Dが複数個設けられ、基準マーク37A～37Dも複数個設けられている。しかしながら、例えば1個の基準マーク35A及び1個の基準マーク37Aのみを使用しても、レチクル12だけを走査して計測結果を平均化することにより、レチクル12上のパターン描画誤差の影響を低減できる。

【0107】次に、本発明の第2実施例につき、図15及び図16のフローチャートを参照して説明する。これに関して、上述の第1実施例のレチクルアライメントモードはレチクル上の4組のファインアライメントマーク29A～29D、30A～30Dを使用して、ファインのレチクルアライメントを行うものであった。しかしながら、第1実施例の方法により1度ファインのレチクルアライメントが行われた後は、スキャン方向のスケール誤差、又はスキャン方向のレチクル座標系とウエハ座標系との平行度が小さい場合等には、1組のファインアライメントマークを使ってレチクルアライメントやベースライン計測を行うようにしてもよい。このように1組のファインアライメントマークを使って非スキャン方向の倍率( $R_x$ )計測、ローテーション( $\theta$ )計測、及びベースライン計測の3項目に対する計測を実施するアライメントモードを「クイックモード」と呼ぶ。このクイックモードは、更にレチクル12上のファインアライメントマーク29A～30Dの描画誤差が小さいことが予め分かっている場合にも、適用することができる。

【0108】このクイックモードでは、例えば、レチクル12上の1組のファインアライメントマーク29A、30Aと、基準マーク板6上の1組の基準マーク35A、36Aと、基準マーク板6上の1つの基準マーク37Aとを使って、非スキャン方向の倍率( $R_x$ )計測、ローテーション( $\theta$ )計測、及びベースライン計測の3項目に対する計測を実施する。但し、このクイックモードの場合、1組のファインアライメントマーク29A、30Aの描画誤差を補正するためには、ファインアライメントシーケンスで求めた、マーク29A、30Aの描画誤差を記憶しておく必要がある。

【0109】この第2実施例の動作を図15及び図16を参照して説明する。図15及び図16の動作は、図2の動作にクイックモードを加えた動作であり、ファインモードとクイックモードとが切り換え可能となっている。図15のステップにおいて、図2のステップに対応するステップには同一符号を付してその詳細説明を省略する。

【0110】図15において、ステップ101～104については図2の場合と同様に、レチクルホルダー上にレチクル12を載置し、ラフサーチ用アライメントマーク27及び28の位置をそれぞれRA顕微鏡19及び20にて検出する。次に、ステップ115でファインモードとクイックモードとのどちらか一方を選択する。この

選択結果は予め図1のキーボード22Cを介してオペレータから指示されている。但し、不図示のバーコード・リーダーによりレチクル12のパターン情報等を読み取り、この結果に基づいて主制御系22Aが自動的にアライメントモードを選択するようにしてもよい。

【0111】ファインモードが選択されると、図15のステップ105～113が実行され、前述の如く複数のファインアライメントマークと複数の基準マークとを使ったレチクルアライメント及びファインアライメントの計測結果を使ったベースライン計測が実行される。そして、ステップ114で、レチクル12上の新座標系上において、本来の位置に対する実際のファインアライメントマーク29A及び30Aの位置の描画誤差（以下、「マーク誤差」という）を求め、そのマーク誤差を主制御系22A内の記憶部に記憶する。マーク誤差を求める際には、ステップ113で求めた関係（変換パラメータ）より、ウエハ座標系を基準としてレチクル座標系を求め、このレチクル座標系上でファインアライメントマーク29A～29D、30A～30Dの設計上の座標値に対する計測された座標値の非線形誤差を求める。この非線形誤差がマーク誤差となる。このようにして、ファインアライメント時に、ステップ112、113の結果からレチクル上の新座標系上でのマーク誤差を記憶しておく。また、レチクル描画誤差を予め計測してある場合は、オペレータが描画誤差を直接入力してもよい。描画誤差に線形成分が含まれる時は特に効果が大きい。

【0112】一方、ステップ115でクイックモードが選択されると、動作は図16のステップ116に移行する。そしてステップ116～118において、図15のステップ105～107と同じ動作を実行する。即ち、クイックモードでレチクル12上の1対のファインアライメントマーク30A、29A、及び基準マーク板6上の1対の基準マーク36A、35Aの像をRA顕微鏡により観察し、オフ・アクシス方式のアライメント装置34によって1個の基準マーク37Aを検出する。また、ステップ119の後半で、RA顕微鏡で観察したマーク、及びオフ・アクシス方式のアライメント装置34で検出したマークの位置を求める。その後、ステップ119において、レチクル12上のファインアライメントマーク30A、29Aの検出された位置に対して、図15のステップ114で求めたマーク誤差の補正を行う。これにより、クイックモードで計測するマークの個数は少なくとも、レチクル12上のパターン描画誤差は第1実施例のファインアライメントモードの場合とほぼ同程度に補正できる。

【0113】次に、ステップ120において、ステップ119での補正により得られた各マークの位置に基づいて、(数9)の6個の変換パラメータ( $R_x$ ,  $R_y$ ,  $\theta$ ,  $\omega$ ,  $O_x$ ,  $O_y$ )の内の、非スキャン方向の倍率誤差 $R_x$ 、ローテーション $\theta$ 、及びオフセット $O_x$ ,  $O_y$

を求める。具体的には、図8(a)及び(c)に示すように、実測した基準マーク35A、36AのX方向(非スキャン方向)のマーク間隔と、マーク像29AW、30AWのX方向の間隔との差から非スキャン方向の倍率誤差 $R_x$ を求める。更に、基準マーク35A、36AのY方向(スキャン方向)の位置ずれと、マーク像29AW、30AWのY方向の位置ずれとの差、及びマーク間隔からローテーション $\theta$ を求める。また、オフセット $O_x$ 、 $O_y$ は基準マークとレチクルのマーク像との平均的な位置ずれ量から求められる。

【0114】なお、このクイックモードでは、計測対象とするマークはレチクル側と基準マーク板6側とで2個ずつであるため、(数9)の6個の変換パラメータの内の4個の変換パラメータしか決めることができない。そこで、上述のように4個の変換パラメータの値を求めている。なお、例えば図4のY方向に並んだ2個のファインアライメントマーク29A、29D、及び図8(c)の2個の基準マーク35A、35Dを計測対象と選択することにより、走査方向の倍率誤差 $R_y$ を求めることができる。

【0115】そして、ステップ120で求められた非スキャン方向の倍率誤差 $R_x$ 、ローテーション $\theta$ 、及びオフセット $O_x$ 、 $O_y$ に基づいてレチクルアライメントが行われる。なお、倍率誤差の計測は、各マークの設計値に対する各マークの計測値のずれ分に対応する倍率誤差を予めテーブルとして用意しておき、各マークの設計値に対する各マークの計測値のずれ分をそのテーブルに当てはめて倍率誤差を求めるようにしてもよい。

【0116】次に、ステップ121において、基準マーク35A、36Aの中心座標の計測値と基準マーク37Aの計測値とを使ってベースライン計測を行う。このように、本実施例によれば、一度ファインアライメントモードを実行してレチクル12のパターンの描画誤差(マーク誤差)を求めておき、クイックモードでアライメントを実行する場合には、そのマーク誤差の補正を行っているため、高いスループットで且つ高精度にスリットスキャン方式の投影露光装置のアライメントを行うことができる。

【0117】次に、本発明の第3実施例につき図17のフローチャートを参照して説明する。この第3実施例は、ウエハを所定枚数交換する毎に、即ち所定枚数のウエハに露光を行う毎に、上述のクイックモードでレチクルアライメントとベースライン計測とを行うものである。本実施例において、図1の投影露光装置でレチクルを交換した後、例えば数100枚のウエハにレチクル12のパターンを順次露光する場合の動作の一例を図17を参照して説明する。

【0118】まず、図17のステップ211において、前に使用したレチクルを図1のレチクル12に交換して露光動作が開始される。この際には図15のステップ1

01~104及び115、並びに図16のステップ116~121に示す、クイックモードのレチクルアライメント及びベースラインチェックの動作が実行される。その後、ステップ212で変数Nに初期値として、次にレチクルアライメント及びベースラインチェックを行うまでに露光するウエハの枚数を設定し、ステップ213でウエハをウエハステージ4上にロードする。但し、ステップ213で既に露光されたウエハがあるときにはその露光済みのウエハのアンロード(搬出)を行った後に新たなウエハのロードを行う。

【0119】次に、ステップ214で変数Nが0であるかどうか、即ちレチクルアライメント及びベースラインチェックを行うタイミングであるかどうか調べられ、変数Nが0より大きい場合にはステップ215で変数Nから1を減算してステップ216に移行する。このステップ216では、図13のオフ・アクシス方式のアライメント装置34又はTTL方式のウエハアライメント系を用いてウエハのアライメントを行った後、ウエハの各ショット領域にレチクル12のパターンが露光される。全部(指定枚数)のウエハへの露光が終了すると、そのレチクル12に関する露光工程は終了するが、全部のウエハへの露光が終わっていない場合には、ステップ213に戻って露光済みのウエハのアンロード及び新たなウエハのロードが行われる。その後動作はステップ214に移行する。

【0120】また、ステップ214で $N=0$ 、即ちレチクルアライメント及びベースラインチェックを行うタイミングである場合にはステップ217においてレチクル12の回転誤差及び倍率誤差の計測が行われる。これは図16のステップ120と同様である。その後、ステップ218に移行し、ここでオフ・アクシス方式のアライメント装置34(FIA光学系48を含むアライメント系又はLIA光学系52を含む2光束干渉アライメント方式のウエハアライメント系)のX方向及びY方向のベースラインチェックが行われる。その後、ステップ219で変数Nとして次にベースラインチェックを行うまでに露光するウエハの枚数を設定してから、動作はステップ216に戻る。

【0121】このように、本実施例によれば、レチクルを交換する毎に、レチクルアライメント及びベースライン計測を行うと共に、所定枚数のウエハに露光を行う毎にクイックモードでレチクルアライメント及びベースライン計測を行っているため、高いスループットで各ウエハとレチクルのパターン像との重ね合わせ精度を高めることができる。

【0122】また、上述実施例の手法はオフ・アクシス方式のアライメント時のベースライン計測について説明してあるが、投影光学系のフィールド内を用いたTTL(スルー・ザ・レンズ)方式においても本発明の適用により同様の効果が期待できる。このように、本発明は上



述実施例に限定されず、本発明の要旨を逸脱しない範囲で種々の構成を取り得る。

#### 【0123】

【発明の効果】本発明の第1の投影露光方法によれば、最終的に、例えばマスク上の複数の計測用マークの各位置で求められた位置ずれに合わせて、最小自乗近似等によって、マスク座標系と基板座標系とを対応付けるパラメータ（倍率、走査方向のスケーリング、回転、走査方向の平行度、X方向及びY方向のオフセット）を求めることにより、マスク上の計測用マークの描画誤差の影響を小さく抑えることができる。

【0124】また、第2の投影露光装置によれば、マスク側の複数の計測用マークに関する計測結果を平均化することにより、マスクの計測用マークの描画誤差を小さくして、投影光学系の基準点とアライメント系の基準点との間隔であるベースライン量を正確に計測できる。また、第3の投影露光装置によれば、基準マーク部材上に、マスク上の複数の計測用マークに対応させてその第1の基準マークを複数個形成すると共に、これら複数の第1の基準マークからそれぞれ投影光学系の露光フィールド内の基準点とオフ・アクシス方式のアライメント系の基準点との間隔に対応する間隔でその第2の基準マークを複数個形成しているため、基準マーク側でも平均化が行われるので、より正確にベースライン量が計測される。

【0125】また、本発明の第4の投影露光方法によれば、クイックモードによる簡易的な計測工程を選択することにより、必要に応じて高いスループットでマスク上の座標系とステージ上の座標系との対応関係を求めることができる。また、第5の投影露光方法によれば、クイックモードによる簡易的な計測工程を選択することにより、必要に応じて高いスループットでマスク上の座標系とステージ上の座標系との対応関係、及びベースライン量を求めることができる。

【0126】また、第6の投影露光方法によれば、所定枚数の基板に露光を行う毎に、クイックモードによる簡易的な計測工程を実行しているため、多くの基板に連続的にスキャン方式で露光を行う場合に、高いスループットでマスク上の座標系とステージ上の座標系との対応関係、及びベースライン量を求めることができる。

#### 【図面の簡単な説明】

【図1】本発明による投影露光方法の実施例が適用される投影露光装置を示す構成図である。

【図2】第1実施例のアライメント方法及びベースライン量のチェック方法を示すフローチャートである。

【図3】レチクルローダー系を示す斜視図である。

【図4】（a）はレチクル上のアライメントマークの配置図、（b）は投影光学系の有効視野と共役な領域でのアライメントマーク等を示す配置図、（c）はファインアライメントマーク29A～30Dを示す拡大図であ

る。

【図5】（a）はレチクルの大まかなアライメントを行う場合の説明図、（b）は図5（a）を縮小した図である。

【図6】レチクルの大まかなアライメントを行うときに撮像素子から得られる種々の撮像信号を示す波形図である。

【図7】（a）はウエハ側のステージの平面図、（b）はレチクル側のステージの平面図である。

【図8】（a）はレチクル上のマーク配置を示す投影図、（b）はレチクル上のマークの一例を示す拡大投影図、（c）は基準マーク板6上の基準マークの配置を示す平面図、（d）は基準マーク35A等の一例を示す拡大図、（e）は基準マーク37A等の一例を示す平面図である。

【図9】レチクルアライメント及びベースライン量の計測時の基準マーク板、レチクル、投影光学系及びアライメント装置の関係を示す平面図である。

【図10】レチクルアライメント及びベースライン量の計測により得られる誤差ベクトルを示す図である。

【図11】レチクルアライメント顕微鏡19及び照明系の構成を示す一部を切り欠いた構成図である。

【図12】（a）は図11の撮像素子で観察される画像を示す図、（b）及び（c）はその画像に対応するX方向及びY方向の画像信号を示す波形図である。

【図13】オフ・アクシス方式のアライメント装置34を示す構成図である。

【図14】（a）は図13の撮像素子で観察される画像を示す図、（b）及び（c）はその画像に対応するX方向及びY方向の画像信号を示す波形図、（d）及び（e）は図13のLIA光学系を介して得られる検出信号を示す波形図である。

【図15】第2実施例のアライメント方法及びベースライン量のチェック方法の一部の動作を示すフローチャートである。

【図16】第2実施例のアライメント方法及びベースライン量のチェック方法の残りの動作を示すフローチャートである。

【図17】第3実施例の露光方法の動作を示すフローチャートである。

【図18】従来のステッパーのアライメント系を示す一部を切り欠いた構成図である。

#### 【符号の説明】

- 4 Zθ軸駆動ステージ
- 5 ウエハ
- 6 基準マーク板
- 7 ウエハ側の移動鏡
- 8 投影光学系
- 11 レチクル微小駆動ステージ
- 12 レチクル



35

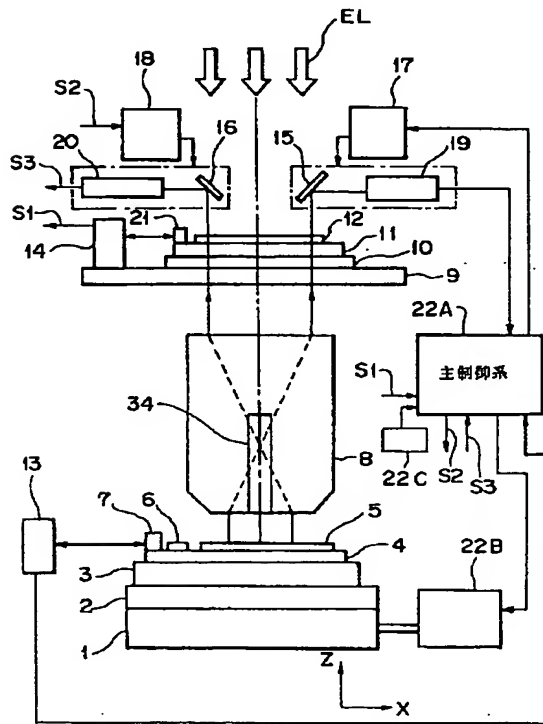
36

- 19, 20 レチクルアライメント顕微鏡 (RA顕微鏡)  
 21 レチクル側の移動鏡  
 27, 28 ラフサーチ用アライメントマーク  
 29A~29D, 30A~30D ファインアライメン

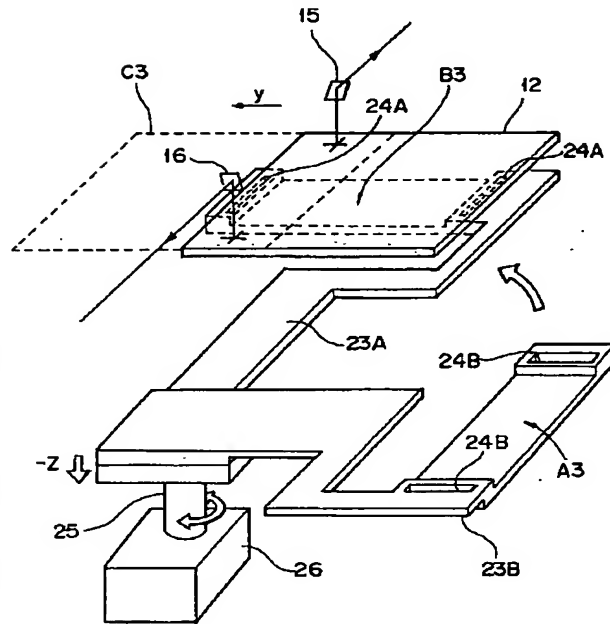
トマーク

- 34 オフ・アクシス方式のアライメント装置  
 35A~35D, 36A~36D 基準マーク  
 37A~37D 基準マーク

【図1】

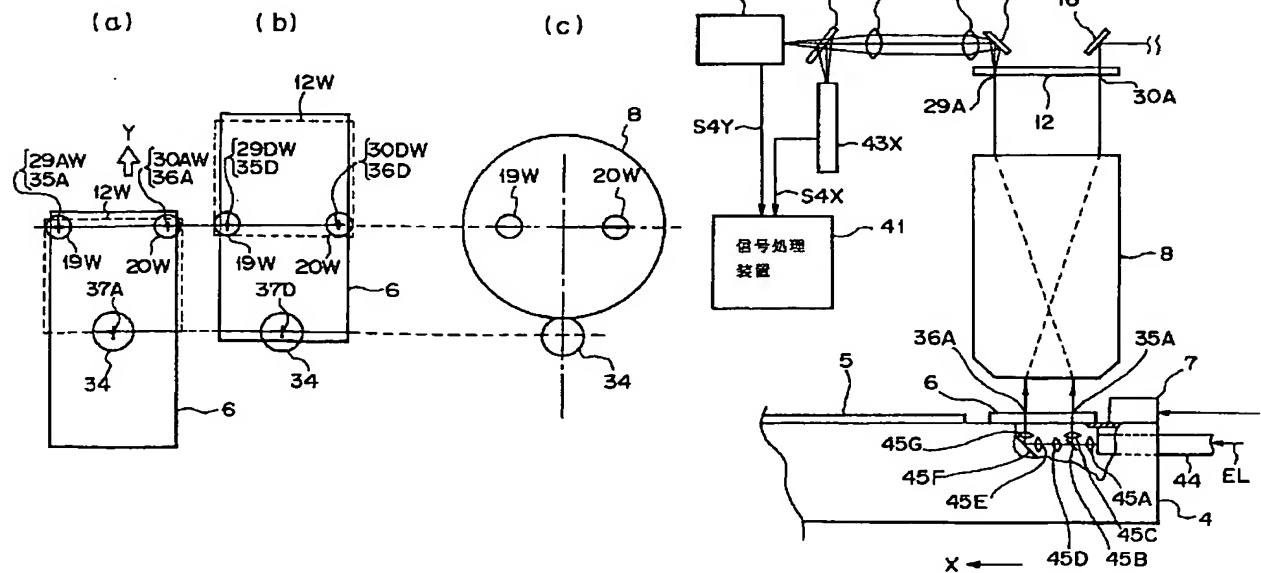


【図3】

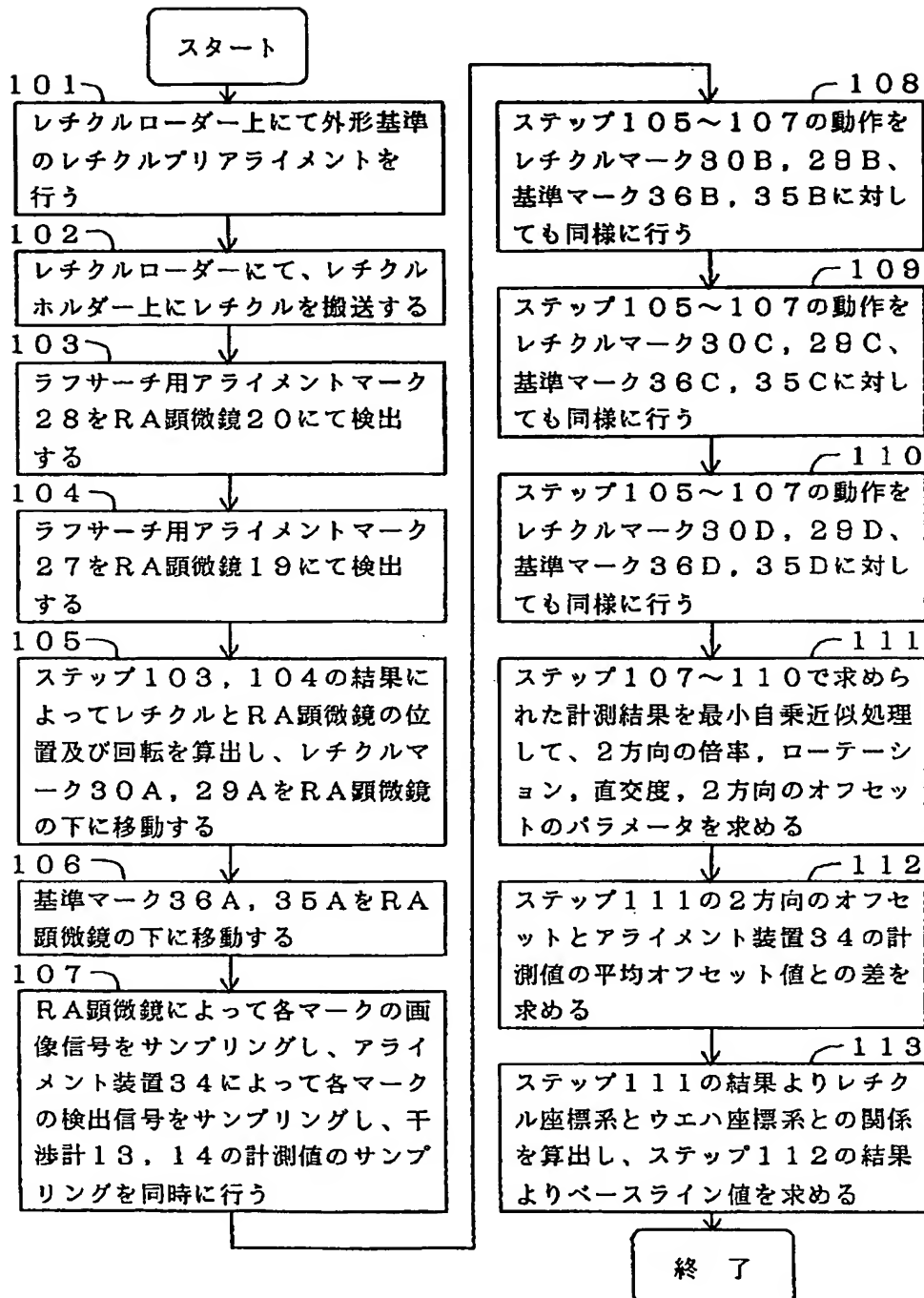


【図11】

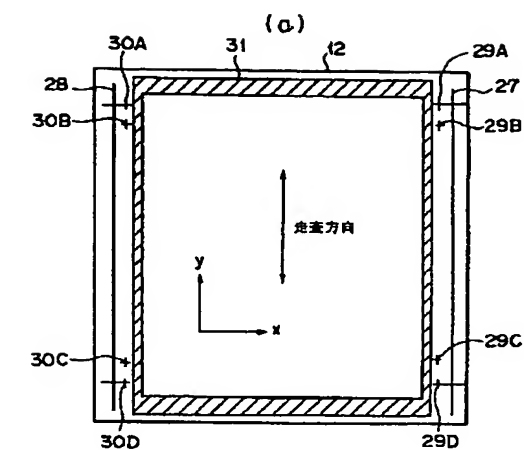
【図9】



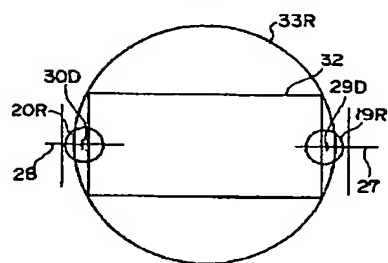
【図2】



【図 4】



(b)

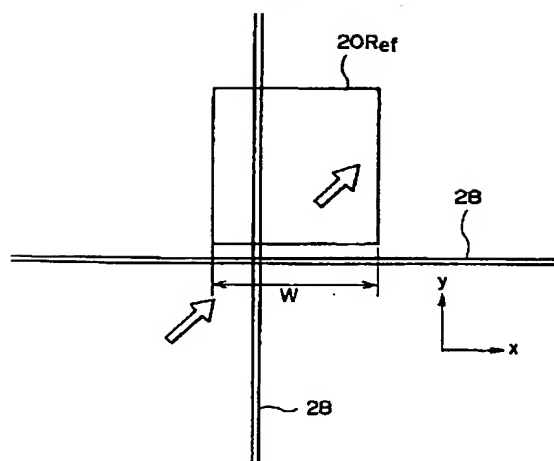


(c)

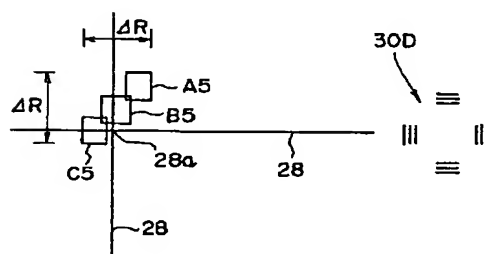


【図 5】

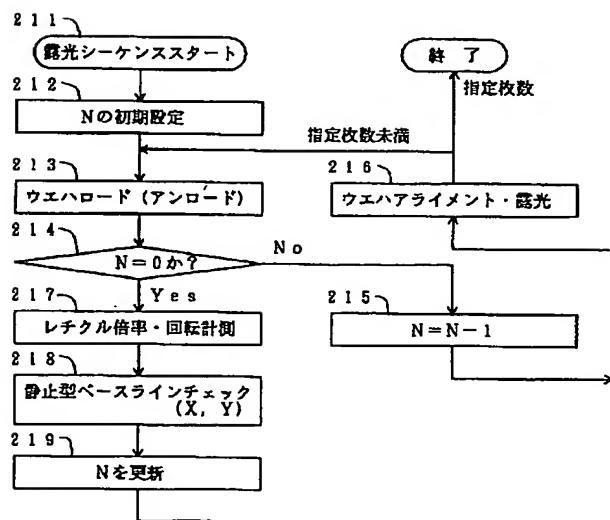
(a)



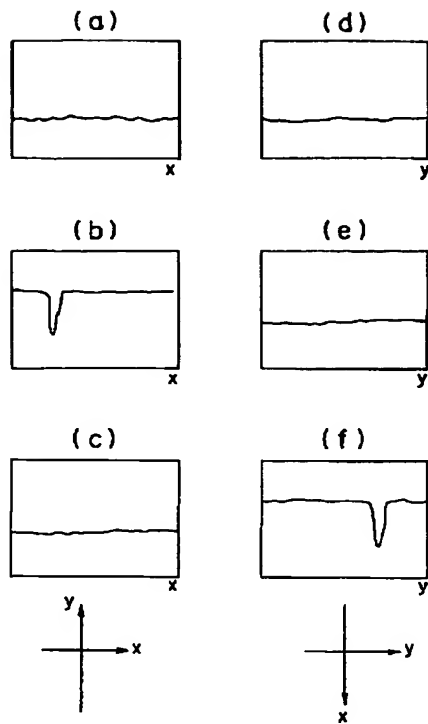
(b)



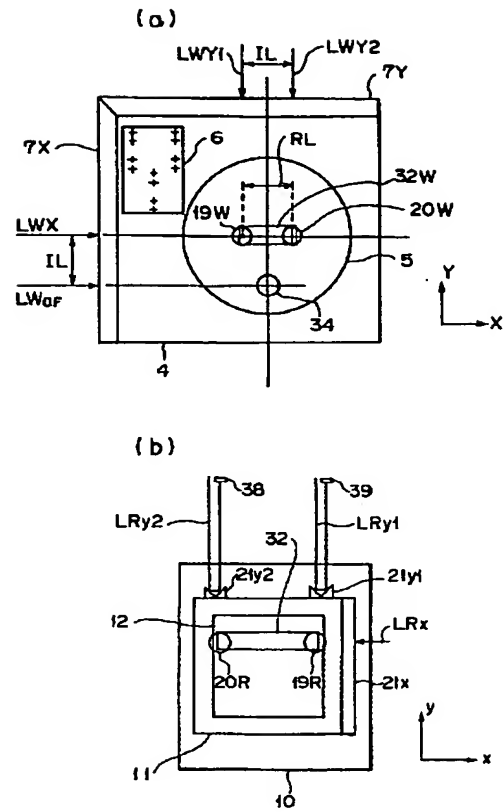
【図 17】



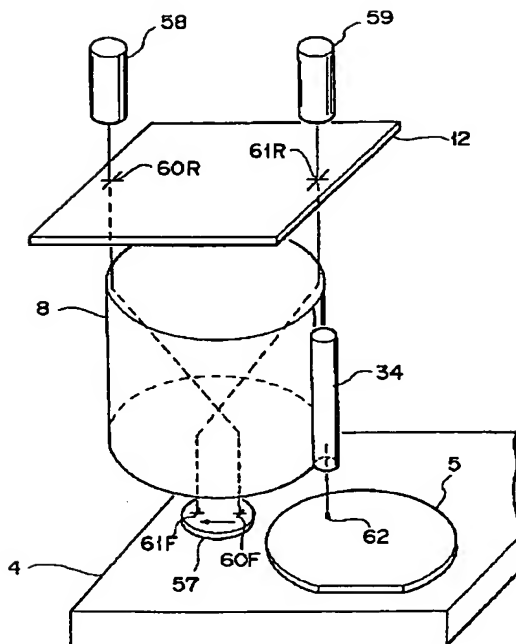
【図6】



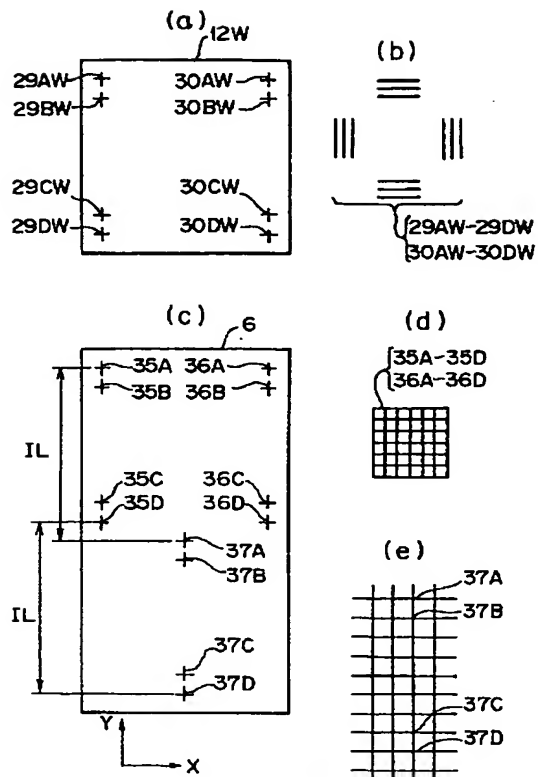
【図7】



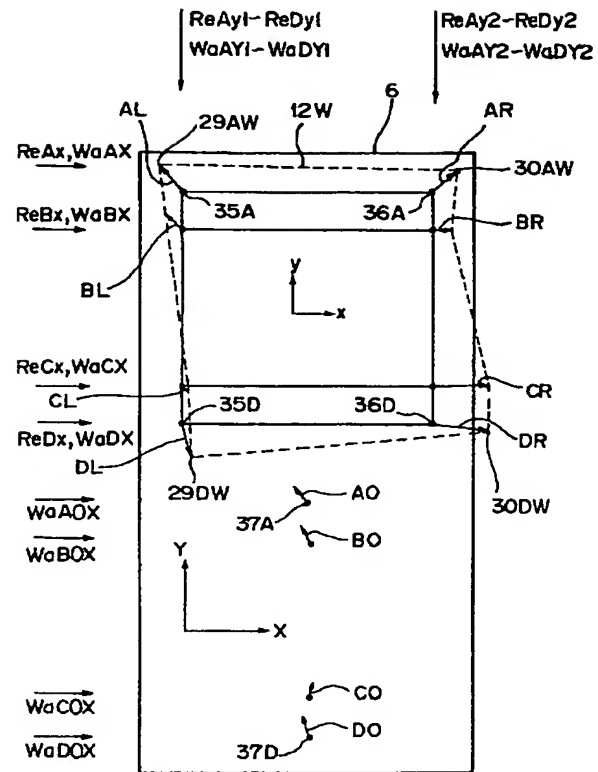
【図18】



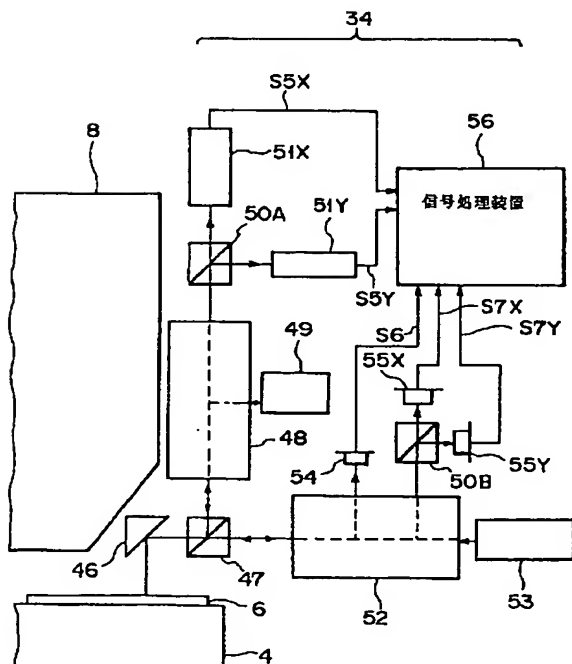
【図 8】



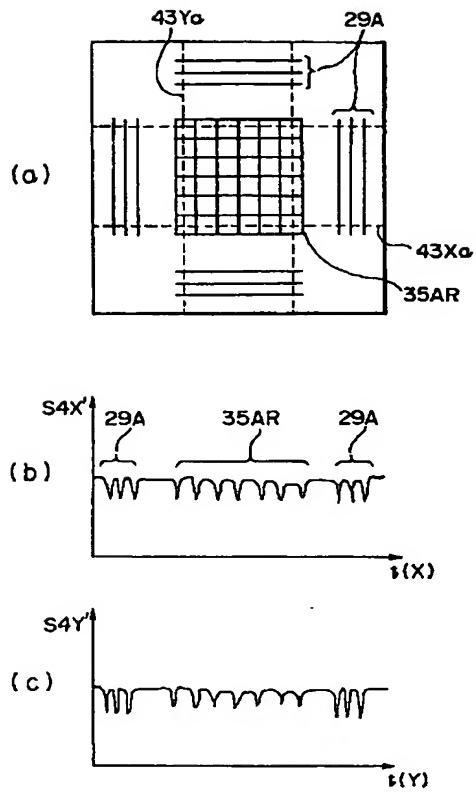
【図 10】



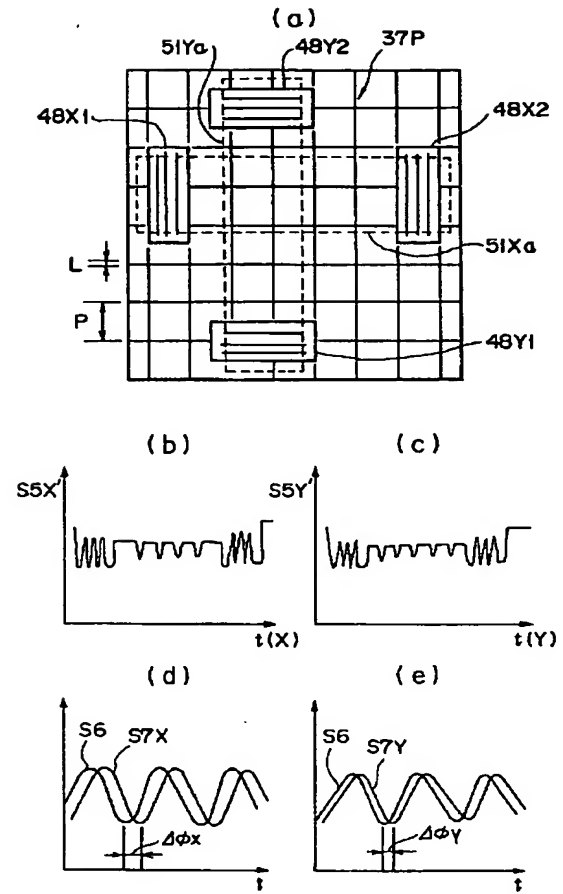
【図 13】



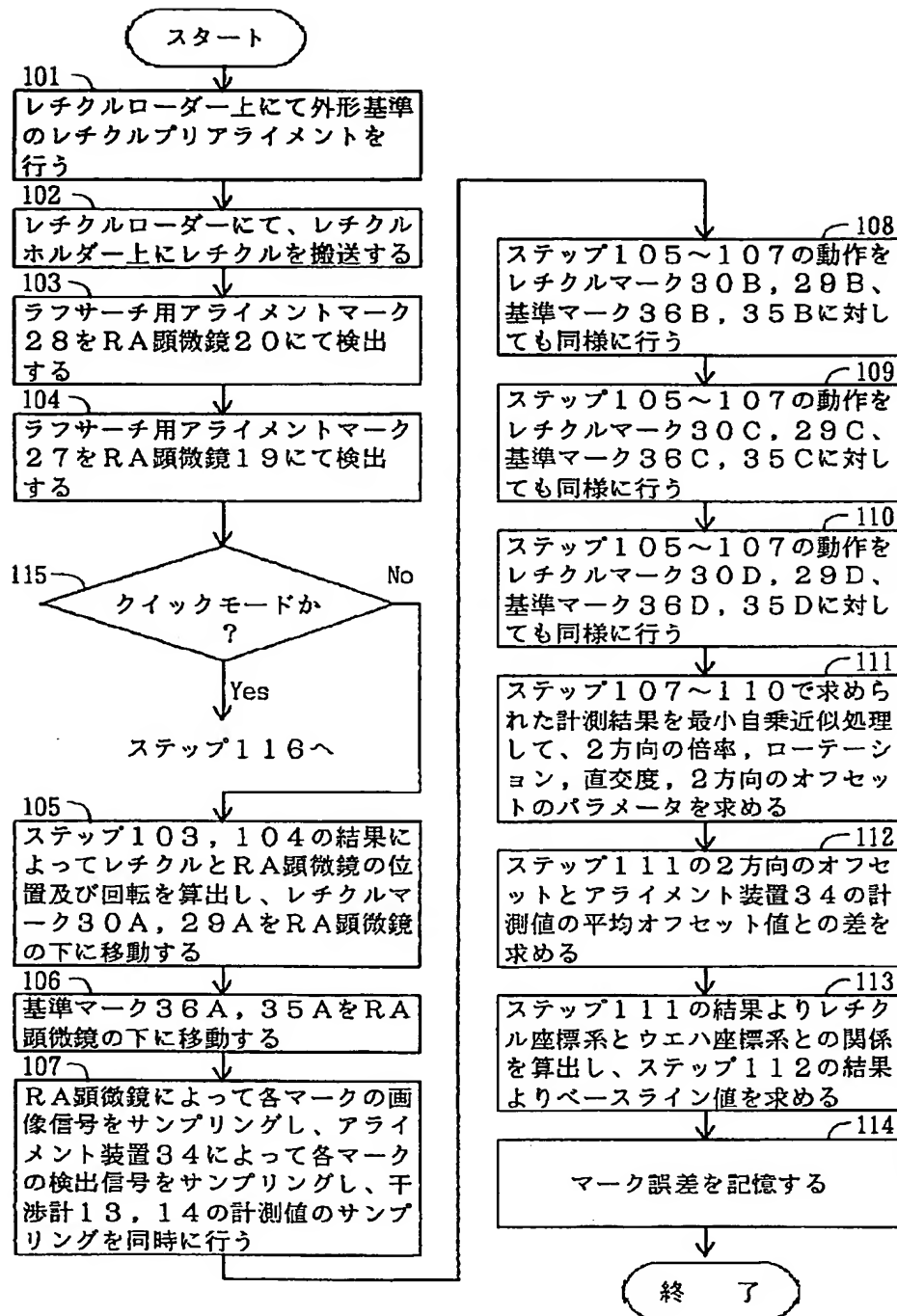
【図 12】



【図 14】

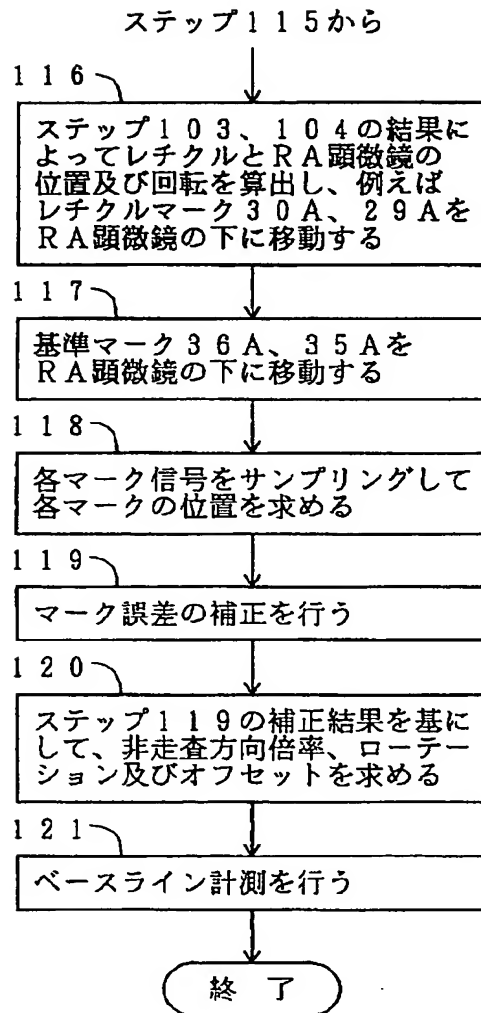


【図15】





【図 16】



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